DOCUMENT RESUME

ED 376 019 SE 053 531

TITLE	Grants for Science Education, 1992-1993.
INSTITUTION	Howard Hughes Medical Inst., Chevy Chase, MD. Office of Grants and Special Programs.
PUB DATE	93
NOTE	141p.
AVAILABLE FROM	Howard Hughes Medical Institute, Office of Grants and Special Programs, 4000 Jones Bridge Road, Chevy Chase, MD 20815-6789.
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	*Biomedicine; *Grants; Higher Education; *Research; *Science Education; Secondary Education

ABSTRACT

To help strengthen education in medicine, biology, and related sciences, the Howard Hughes Medical Institute (HHMI) launched a grants program in these areas in 1987. The grants support graduate, undergraduate, precollege and public science education, and fundamental biomedical research abroad. This document provides summaries of all projects receiving grants in 1992 and is also, in effect, a 1992 annual report for each Programmatic Area supported by HHMI. (ZWH)

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Howard Hughes Medical Institute

Grants for Science Education

1992–1993

Office of Grants and Special Programs

ED 376 019

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Howard Hughes Medical Institute

Grants for Science Education

1992–1993

Office of Grants and Special Programs

Howard Hughes Medical Institute

The mission of the Howard Hughes Medical Institute is biomedical research and education. The twofold concern of the research program is the investigation of fundamental questions in modern biology and application of recent advances in scientific knowledge to the alleviation of disease and the promotion of health. Institute laboratories at more than 50 leading academic medical centers, hospitals, and universities throughout the United States are conducting research in five principal areas: cell biology and regulation, genetics, immunology, neuroscience, and structural biology.

In the fall of 1987, the Institute launched a grants program to help strengthen education in medicine, biology, and related sciences, complementing the Institute's research program. The grants support graduate, undergraduate, precollege and public science education, and fundamental biomedical research abroad. Future support is planned for studies on health sciences policy. In addition, the Office of Grants and Special Programs is undertaking a comprehensive assessment effort.

The Howard Hughes Medical Institute was founded in 1953 by aviator-industrialist Howard R. Hughes. Its charter, in part, reads:

The primary purpose and objective of the Howard Hughes Medical Institute shall be the promotion of human knowledge within the field of the basic sciences (principally the field of medical research and medical education) and the effective application thereof for the benefit of mankind.

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Preface

By supporting science education at all levels, the grants program of the Howard Hughes Medical Institute complements the Institute's core program of direct conduct of biomedical research, which involves some 225 investigators at more than 50 leading academic centers, hospitals, and research institutions in the United States. The fields encompassed by the research include cell biology and regulation, genetics, immunology, neuroscience, and structural biology.

Since launching the grants program five years ago, the Institute has developed an array of initiatives designed to help ensure the future quality and vitality of the scientific enterprise. Today, the Institute supports graduate students, medical students, and physicians through a grants program for graduate education in the biological sciences; undergraduate institutions through an undergraduate science education program; and science museums through a precollege and public science education program. Details of these activities are presented in other sections of this report.

The National Picture

At the end of World War II, scientific and educational possibilities seemed boundless. Commenting on that era, Dr. Hanna Gray, president of the University of Chicago, has noted, "The unlimited possibilities to be anticipated from the progress of basic research and the social and economic goods it would produce appeared to provide a motto and platform for national investment." Visiting the United States in 1966, Malcolm Muggeridge, the noted British journalist, wrote that "higher education is booming in the United States. The gross national mind is mounting along with the gross national product."

More recently, however, science appears to have lost some of its appeal to young men and women, despite the extraordinary opportunities that modern science offers. Studies of students as they proceed through high school, college, and graduate school reveal a consistent loss of potential scientists at key points in their education. More than 75 percent of all high school sophomores express no interest in science and engineering. Of those who do show some interest, about half lose their enthusiasm for science during high school. About 60 percent of the students who retain their early interest are still involved in science and engineering when they graduate from college, and only about one-third of them pursue graduate studies in science and engineering. The patterns are similar for women and underrepresented minority students, except that the initial populations of students are smaller. One major objective of the Institute's grants program is to increase the proportion of students who pursue graduate studies in science and engineering or medical school.

Drs. Nancy M. Hewitt and Elaine Seymour, in a report prepared for the Alfred P. Sloan Foundation, note that "not only do sciences have the highest defection rates of any undergraduate major, their losses come from a pool of disproportionately able students .... A consistently higher proportion of students who are academically able and well-prepared in high school science and mathematics enter science, mathematics, and engineering majors than enter non-science, mathematics, and engineering majors."

Seeking greater involvement of students in science careers—particularly women and minority students traditionally underrepresented in science—the Institute's grants program continues to extend the boundaries of the science education community reached by its initiatives. In 1992, the Precollege and Public Science Education Initiative for Museums awarded its first grants to science museums. In the coming years these grants will provide science education activities, particularly for populations underrepresented in the sciences, in both cities and rural areas. With the 1993 grants competition, the undergraduate program enters a new phase in its development. The program will support undergraduate laboratory research experiences, including opportunities for women and underrepresented minority students; equipment acquisitions and laboratory renovations; and precollege and other outreach initiatives.

Information exchange within and between laboratories is an essential process of research and science education, as noted by Frederick Grinell in his recent book *The Scientific Attitude*. When scientific investigators welcome students and postdoctoral fellows to their laboratories, "the continuity of science is established, and there is a certain sense of immortality in passing down one's thought style. In addition, and possibly of greater importance, the presence of students and fellows expands the thought style of the laboratory." In keeping with the style of science, the Institute has structured a number of opportunities for grantees to meet, exchange information, and expand their styles of thought.

In 1990, the Institute began a series of annual meetings for recipients of its fellowships and grants. This year the Institute again held a scientific meeting for medical student research fellows and a second annual meeting of undergraduate program directors. Next year the Institute expects to add meetings for some of the predoctoral and physician research fellows and for program directors from museums. The Institute publishes abstracts and proceedings for these meetings, which are disseminated to interested persons and institutions throughout the world.

The International Picture

The importance of international support and cooperation in science was made clear nearly a half century ago in Vannevar Bush's seminal report *Science–The Endless Frontier.* "Perhaps more than any other national activity," the report noted, "scientific research and development depend upon close relationships with other countries. Scientific knowledge is not limited by geographical or racial boundaries, and it is almost impossible to think of any branch of science which has progressed very far without amalgamating discoveries made in several different nations." Indeed, the international nature of biomedical and other scientific disciplines is underscored by the fact that almost one out of every three of the investigators supported by the scientific program of the Institute, as part of his or her previous professional education and training either received a degree from an institution outside the United States or conducted postdoctoral work abroad.

The first awards in the Institute's program of research grants abroad were made in 1991, for scientists in Canada and Mexico. The United Kingdom, Australia, and New Zealand were eligible for the most recent competition. In that competition, the Institute awarded five-year grants for a total of $2.7 million annually to support the research of 29 outstanding investigators designated by the Institute as international research scholars.

The first research grants awarded by the Institute under the international initiative are already providing exciting results, as indicated by the scientific publications of Canadian and Mexican scientists supported by the Institute. Summaries of the scholars' grant-supported investigations are also included in *Research in Progress* and the *Annual Scientific Report,* two major publications of the Institute. Since September 1991, the scholars have had the opportunity to exchange scientific information and ideas with Institute investigators annually at Institute-sponsored scientific meetings in Bethesda, Maryland.

An Institute-supported seminar on the molecular biology of parasites provided another excellent opportunity for scientific exchange. The meeting, held at the National University of Mexico in October 1992, was organized with support from grants awarded to the U.S. National Academy of Sciences and the Mexican Academia de la Investigación Científica, for joint activities. Sixteen U.S. scientists and eight Mexican scientists made presentations, including two of the Institute's international research scholars, Dr. Paul Modesto Lizardi and Dr. M. Esther Orozco.

The Institute's international programs fit well with the principles described in *Science–The Endless Frontier.* "It is part of our democratic creed," the report noted, "to affirm the intrinsic cultural and aesthetic worth of man's attempt to advance the frontiers of knowledge and understanding. By that same creed the prestige of a nation is enhanced by its contributions—made in a spirit of friendly cooperation and competition—to the worldwide battle against ignorance, want, and disease."

Purnell W. Choppin
President
Howard Hughes Medical Institute

Introduction

"Ever since I was in grade school," wrote Lorraine Hernandez in her successful application to become a Howard Hughes Medical Institute predoctoral fellow in the Department of Biochemistry at the University of California, San Francisco, "I wanted to be a scientist, but at that time I had no idea of what a scientist did. As I went through high school, I not only discovered what scientists did but that there were many different areas of science. So upon entering college my biggest problem was choosing a major. I only knew it had to be in the biological sciences since that is what I loved....I would eventually like to study diabetes or leukemia. My interest stems from the fact that these diseases have affected close members of my family."

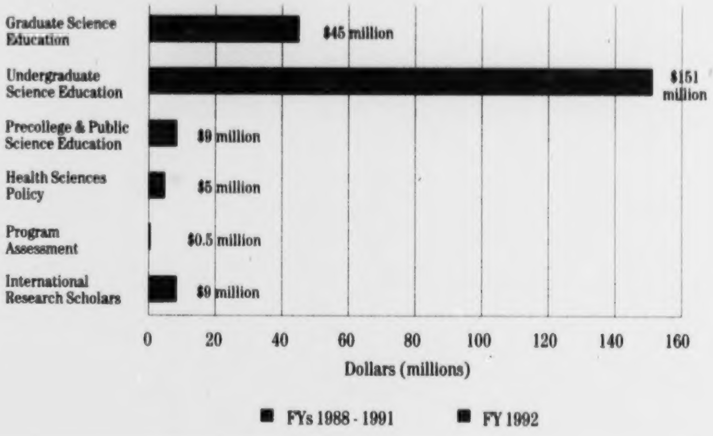
As an undergraduate at the University of Arizona, Ms. Hernandez had the opportunity to learn about research first-hand. She participated in research activities under the aegis of the Institute's Undergraduate Biological Sciences Education Program at the University, where she studied heat shock proteins in plants. Ms. Hernandez is representative of over 7,800 undergraduates who have benefited from the opportunity to conduct research at 181 academic institutions under the Institute's undergraduate program.

The Institute's Office of Grants and Special Programs is a major contributor to the support of science education through fellowships to medical, graduate, and postdoctoral students; science-related grants to undergraduate institutions; grants to expand educational activities in science museums; and other activities. The Institute is beginning its sixth year of operations to strengthen education in biology, medicine, and related sciences and to support other activities designed to attract students to careers in biomedical research and teaching.

This report highlights grant awards and program activities for 1992, as well as policies for each of the programs for 1993. The grants office 1993 budget for science education is approximately $50 million, including $15 million for Graduate Education in the Biological Sciences, $27 million for the Undergraduate Biological Sciences Education Program, and $8 million for other programs including Precollege and Public Science Educa-

Figure 1

**Howard Hughes Medical Institute
Grants Program Expenditures, 1988-1992**



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tion, the International Research Scholars Program, and Program Assessment.

The First Five Years

Program Initiatives

In 1988, the Institute began its graduate education program, one of the first initiatives established by the grants program. After five rounds of awards the Institute now provides $7.5 million annually to about 300 fellows through the Predoctoral Fellowships in Biological Sciences Program. Sixteen of these students to date have successfully defended their theses. The first awards under another program in graduate education, Research Training Fellowships for Medical Students, which provides for one year of full-time fundamental research, began in 1989. This past year the Institute provided $2.2 million in awards to 60 medical students for a year of research and to about 40 more medical students for continued fellowship activities. A third program of fellowship awards, the Postdoctoral Research Fellowships for Physicians, began in 1990 and provides support for three years of full-time research. Nearly $5 million was provided this past year to support the training of 69 physician research fellows.

Since 1988 the Institute's Undergraduate Biological Sciences Education Program has supported colleges and universities in strengthening education in biological sciences, and chemistry, physics, and mathematics as they relate to biology. The Institute has now provided a total of $175.5 million to 181 institutions. These five-year grants have provided research opportunities to 7,800 undergraduates, the appointment of 114 new science faculty members, equipment upgrades and development of about 1,700 courses covering a wide range of scientific disciplines, and the involvement of 16,000 primarily elementary and secondary students and about 5,400 teachers in precollege outreach programs. In 1992, the Institute completed a fourth round of competition and awarded undergraduate grants totaling $52.5 million to 42 institutions.

The Institute has also developed initiatives in precollege and public science education that focus on children and youth in elementary and secondary schools, provide a bridge to science programs developed by museums, and involve teachers, families, and community groups. Under its Precollege and Public Science Education Initiative, the Institute in 1992 awarded $6.4 million in grants to 29 institutions, including children's and youth museums, natural history museums, and science and technology centers.

In 1991, the Institute initiated a limited International Research Scholars program on an experimental basis in recognition of the contributions of scientists abroad to advances in biomedical science. In the initial competition, the Institute awarded five-year grants totaling

$10.8 million, to support the research of 14 leading scientists in Canada and 10 in Mexico. In the 1992 competition, 29 outstanding scientists in the United Kingdom, Australia, and New Zealand were designated as Scholars and awarded five-year research grants totaling $13.5 million.

As the Institute's Office of Grants and Special Programs begins its sixth year, materials describing each program are available, and panels of external reviewers have been assembled to review, discuss, and rate the submitted applications and proposals as they have done in previous rounds of competition. An internal Institute committee will review the rank order of the applications and proposals that results from the external panel review and will make recommendations on awards to the Trustees, who authorize funding for all grants.

Over the past five years more than 150 scientists and educators have served on 10 external review panels convened by the Institute. An additional 400 scientists have been convened by the National Academy of Sciences to review predoctoral fellowship applications. The review panels account in large measure for the consistent excellence of the awardees.

In its various program initiatives the Institute has sought to create programs that promote excellence while complementing other sources of available support and meeting special needs. In doing so the Institute has sought to adhere, says Daniel Sullivan of Project Kaleidoscope, an activity of the Independent Colleges Office, to a "compelling vision," namely, that every institution is responsible for enhancing the capabilities in science of all enrolled students, regardless of the students' previous preparation in or motivation for courses or careers in science.

Program Assessment Activities

Sheila Tobias, in her recent report *Revitalizing Undergraduate Science: Why Some Things Work and Most Don't,* observes that in measuring the changes that new programs are expected to produce, "All that's lacking is to decide what constitutes achievement and when is the appropriate time to measure it."

For undergraduate science education, the Institute has assessed prior achievement by measuring the science education productivity at the baccalaureate level of academic institutions throughout the United States. In the section of this report on program assessment, data gathered on science education productivity for more than 1,400 institutions significantly update and expand previous studies to determine these measurements. Science education productivity for these purposes is defined as the absolute number and proportion of baccalaureate graduates that go on to matriculate in medical school or to earn doctoral degrees in the biological sciences and other disciplines. These data are the basis for inviting academic institutions to compete for support in the Institute's under-

> ***Adhere to "a compelling vision," namely, that every institution is responsible for enhancing the capabilities in science of all enrolled students, regardless of ... [their] previous preparation ... or motivation for courses or careers in science.***
>
> *Daniel Sullivan,*
> *Project Kaleidoscope*

graduate science education program. The assessment section of this report also documents Institute activities to monitor the progress of its predoctoral fellows, medical student fellows, and postdoctoral fellows.

An assessment component is also planned for the precollege and public science education programs. The Institute's approach to assessment of its programs also involves, in part, bringing participants together to exchange information and assist the Institute in refining existing programs and developing new ones.

Medical Student Fellows Meeting. As part of its assessment efforts, the Institute in 1990 began a program to assemble grant recipients and provide them with a forum to discuss the results of their Institute-supported activities and offer feedback to the Institute. The medical student fellows were first convened at a May 1990 scientific meeting to discuss their research. This meeting has taken place annually since then. In 1993 the Institute plans to begin a second additional series of scientific meetings, this one for predoctoral and physician research fellows.

At the most recent meeting for medical student fellows, Sharon Bloom, Stanford University School of Medicine, presented her work on the molecular characterizations of wild polioviruses from Vietnam. Wild polioviruses remain a problem in the developing world, causing up to 250,000 cases of paralytic polio each year. Ms. Bloom says, "My life goals remain as clear to me as they were when I first started medical school, namely that by living and working in Southeast Asia, I hope to improve the health of ... children ... Through [the opportunity provided by] the Institute I came to learn the scientific principles and techniques behind pediatric viral disease surveillance."

The fellowship year may play a critical role in the career decisions of these medical students. The unique opportunity for medical students to immerse themselves in research is intended to reinforce an interest in becoming a physician-scientist. Institute fellowships also provide a new source of funding that complements programs funded by the National Institutes of Health and the private sector for medical students seeking research experiences.

Undergraduate Program Directors Meeting. The Institute has embarked on a program to sponsor a series of meetings at which program directors at the institutions receiving Institute awards can exchange information on their activities. The 1992 program directors meeting focused on enriching the undergraduate experience in science through curriculum and laboratory development and undergraduate research. The focus of the 1991 meeting was on undergraduate research and precollege and outreach activities (see *Attracting Students to Science*, Howard Hughes Medical Institute, Bethesda, Maryland 1992). Future meetings will include program directors at colleges and universities that receive awards in subsequent competitions.

Reflecting the theme of the 1992 meeting, presenters discussed several approaches tailored to specific groups of undergraduates at academic institutions for laboratory curriculum development at the introductory through upper-division levels. Programs to link hands-on research to undergraduate laboratory courses were also discussed. Of particular interest were programs that address the development of interdisciplinary laboratories and courses. Presentations and discussions explored the role that stimulating laboratory courses and research opportunities can play in attracting to the sciences women and students from minority groups underrepresented in scientific fields.

Examples of ideas for attracting and retaining students in the sciences, particularly women and underrepresented minorities, that emerged from the meetings include the critical role of mentoring; the importance of precollege outreach efforts, particularly for first-generation, college-bound students; the value of using software to enhance teaching in so-called "dry" laboratories; the need for sufficient time to plan laboratory sessions; and the importance of role models for women and underrepresented minority students as part of a program to encourage their participation in science.

Museum Program Directors Meeting. In September 1993 the Institute will convene in Bethesda the program directors for institutions that have received grants under the Precollege and Public Science Education Initiative. Over the next five years, these awards to science museums will support a variety of science education activities for children and youth and teacher training programs, with special emphasis on reaching minority and disadvantaged populations in rural and urban settings. The goal of the upcoming meeting will be the exchange of thematic and programmatic information of importance for the precollege and public science education program.

The Institute's Graduate Program Experience

The Institute is already seeing superb students who have benefited from the undergraduate grants. About 16 students who have participated in the Institute's undergraduate program at their college or university have been awarded predoctoral fellowships by the Institute. As an undergraduate at Lehigh University, Tricia Serio took part in an Institute-supported undergraduate program that enabled her to work at Hoffmann–La Roche, Inc., as a summer industry intern, where she studied how to select and grow strains of *Streptomyces* to increase their yield of antibiotic. She is currently an Institute predoctoral fellow doing research rotations in different laboratories in the gradu-

Most people can be good teachers on their best days. We want ... people who are good even on a bad day or during a bad year.

Observations Regarding Tenure for Chemistry Faculty Fort Lewis College

ate Department of Molecular Biophysics and Biochemistry at Yale University.

Sophia Colamarino, participating in an Institute-supported program for undergraduates at Stanford University, analyzed how glycine, an amino acid, activates a specific cell receptor. Now an Institute predoctoral fellow and graduate student in neuroscience in the Department of Physiology at the University of California, San Francisco, she recalls her excitement as an undergraduate when ". . . a professor told me that one day when I have discovered something, no matter how small, for that moment in time I will be the only person in the world to know how one piece of the universe works."

Tricia Serio and Sophia Colamarino are examples of students who have benefited from the changes the Institute's program is making possible in undergraduate science education. Dr. Jan Serie, program director for an Institute grant to Macalester College, says, "The non-investigative approach is a poor model for learning. When students stay passive and disengaged, they do not struggle to create meaning from information they gather. They receive information in predigested form. Someone has already done the fun part, the figuring, the guessing, the problem-solving, the synthesis. They receive only the end product without struggle."

Other medical students participated in Institute-supported programs even before they entered college. Keith Amos, for example, currently in medical school at Harvard University, as a high school student participated in the SOAR (Stress on Analytical Reasoning) program, part of an outreach effort supported by Xavier University of Louisiana under the Institute's grant. Mr. Amos was recently featured in *USA Today* as part of its article on the 21-person "All-USA College Academic First Team."

The Institute's Undergraduate Program Experience

Why are some students attracted to and retained in science majors while others are not? One significant factor for undergraduates is the opportunity to work closely with professors whose personal and pedagogical skills enable them to explain course materials, illustrate concepts, and answer questions without intimidating students. The ability of these professors to communicate their enthusiasm for the subject material and their enjoyment of teaching motivates students to become interested in the sciences.

Fort Lewis College, which received a grant from the Institute for undergraduate biological sciences education, exemplifies the approach upon which the Institute has embarked. A document prepared by the Fort Lewis Department of Chemistry states, "Most people can be good teachers on their best days. We want . . . people who are good even on a bad day or during a bad year. We seek some level of undeniable excellence, whether it be in classroom style, indefatigable nurturing, or pedagogical insight. There also must be an irrepressible love for nature and science, to instill in our students a lifelong science interest."

Many participants at the Institute's recent meeting for undergraduate program directors echoed observations and conclusions that Ms. Tobias drew in her recent book. The participants provided not just a quantitative assessment of increased enrollment in new and revised science curricula but qualitative observations of positive student reactions to the impact of the Institute's grants at their respective institutions.

One participant at the 1992 meeting, Dr. Hillel Chiel, associate professor in the department of biology at Case Western Reserve University, observed, for example, that "emphasizing problem solving per se is not the solution. The key issue is nurturing students through the problem-solving experience. How can we do this? One crucial way is to let the teacher show students how he or she solves a problem (including the false starts and dead ends), and to share the reasoning process with them."

Yet, observes Dr. Hanna Gray, president of the University of Chicago, an essential tension exists among university science faculty today between responsibilities for conducting research and for enhancing the quality of undergraduate science education. "Dual citizenship is a fact of life for the scientist and the scholar," she notes. "Each is a member of two significant communities. Both are important. The vocation of the academic and the profession of the investigator may certainly merge; sometimes, they simply manage to co-exist, and at other times they split apart."

Institute-supported programs at undergraduate institutions throughout the country are encouraging research scientists on university faculties to become more involved in teaching undergraduates. These programs, through an emphasis on student research, faculty and curriculum development, and precollege and outreach activities in elementary, middle, and high schools, are emphasizing a hands-on approach to science as part of a national effort to attract and retain students in the sciences.

Ms. Tobias, commenting on the Institute's approach to undergraduate education, notes that "what is interesting about the Howard Hughes program is how very well it meshes with the lesson of the case studies, such as that of Fort Lewis College [supported by the Institute and mentioned above] presented here. The Institute's purpose was institutional change and enlargement of opportunities. It targeted colleges and universities which had already demonstrated a capacity to produce minority graduates in the biomedical sciences, providing 'postperformance' rewards. Its grants were not to individuals for experimentation, but to departments for improvement. The specific line items were general enough

Dual citizenship is a fact of life for the scientist and the scholar; each is a member of two significant communities. Both are important.

Hanna Gray,
University of Chicago

The [Howard Hughes Medical] Institute's purpose was institutional change and enlargement of opportunities. It targeted colleges and universities which had already demonstrated a capacity to produce minority graduates in the biomedical sciences, providing "postperformance" rewards.

Sheila Tobias,
Revitalizing
Undergraduate Science

One very encouraging trend is the increasing involvement of universities in precollege education. Outreach…is beginning to have a real effect.

Leon Lederman,
Former President,
American Association for the Advancement of Science

for each institution to tailor its spending to its own needs, and the time frame, in every instance, was five years—time enough to plan, implement, and assess."

The Institute's Precollege and Public Outreach Experience

Precollege outreach programs can make a significant difference. Dr. Leon Lederman, the former president of the American Association for the Advancement of Science, noted recently, "One very encouraging trend is the increasing involvement of universities in precollege education. Outreach, the initiatives of scientists, is beginning to have a real effect, at least in the vicinity of universities that are involved."

Outreach activities under the Institute's science museum initiative promise to reach elementary students, their parents, and teachers through several creative approaches. For example, the Children's Museum in St. Paul, Minnesota, received an award for its project called *Water, Ni-bi', H_2O* that features a hands-on curriculum for students in the first through sixth grades. The program will connect water exploration with scientific explanations of water and the Ojibway American Indian water stories. Another grant recipient, the Memphis Science Alliance in Memphis, Tennessee, plans a series of science enrichment programs for children and youths living in two public housing projects. The program is sequential and represents a collaborative effort between a local nature center, a science center, a church, and a youth services group.

The Santa Fe Children's Museum in Santa Fe, New Mexico, plans to collaborate with the Life Lab Science Program at the University of California, Santa Cruz, to involve children in kindergarten through twelfth grade and their families in a land restoration project. Over the grant period, families and Museum visitors will create a horticulture garden.

The Next Five Years

New competitions in several program areas are contemplated for the coming years. The Institute plans to award in 1993 about 66 new predoctoral fellowships, 80 medical student fellowships, and 25 postdoctoral fellowships for physicians. Invitations have been extended to 185 institutions classified by the Carnegie Foundation for the Advancement of Teaching as public and private Comprehensive Colleges and Universities I and II, Liberal Arts Colleges I and II, and Schools of Engineering and Technology to compete in a new phase of the undergraduate science education program. In addition, a new competition for 1993 under the Precollege and Public Science Education Program will involve selected aquaria, botanical gardens and arboreta, children's museums, general science museums, natural history museums, science-technology centers, and zoos.

The Institute's assessment program is designed to measure key outcomes of the various grant initiatives and to assist in the development of new initiatives, through studies of national trends in areas such as science education, the national research enterprise, and private and public support for education. Information collected by the Institute from its fellows and grantees, as well as from sources concerned with the national picture of science education and research, will help guide the Institute's grants program development.

New directions in science education appear promising, and the biological sciences are already fulfilling their great potential. Dr. Lewis Thomas believes we are witnessing the greatest revolution in biology and medicine in history. This revolution gained special force with the discovery of the double-helix structure of DNA in 1953 by Drs. James Watson and Francis Crick. Tom Stoppard, the British playwright, noted that in the world of physics there is a ladder from the atom to a grain of sand: classical physics lies above a missing rung on that ladder and quantum physics lies below. Metaphysics is the missing rung. Thanks to Drs. Watson and Crick, scientists now know that in the world of biology the spiral staircase of the DNA molecule holds the secret of life.

More recently, Dr. Watson helped launch the so-called human genome project to define the order of the alphabet for the three billion DNA bases in the human chromosome. Ultimately thousands and thousands of pages in print will describe human genetic heritage—and destiny. The steps in the spiral staircase from the DNA molecule to the human genome are slowly but surely being put in place. Through molecular biology, scientists are scaling the spiral staircase and putting into perspective the crucial role that DNA plays in all living organisms.

But revolutions—in science, education, or other arenas—cannot take place without the appropriate commitment of resources and talent. The Institute is convinced that it must make a major commitment to science education to help train the next generation of scientists and increase the general understanding of science. Such understanding will be critical for effective public oversight and support of science education and biomedical research.

Seth Blackshaw, one of the Institute's predoctoral fellows, wrote in his fellowship application that despite his initial fascination with science as a child, his interest diminished during elementary and middle school and did not reawaken until he was close to graduating from high school.

He wrote, "Towards the middle of my senior year in high school, I underwent an awakening. I encountered a chapter-long description of the basis of molecular biology while reading Douglas Hofstadter's *Gödel, Escher, Bach*, a book I had initially been drawn to by an interest in philosophy and cognitive psychology ... I remember being

> ***[In] my senior year in high school, I ... encountered ... molecular biology while reading Douglas Hofstadter's*** **Gödel, Escher, Bach** ***... I remember being stunned by the beauty and elegance of the system described.***
>
> *Seth Blackshaw*
> *Howard Hughes Medical Insitute*
> *Predoctoral Fellow*

You can stop if you want with "Z," because most people stop with "Z." But not me. In the places I go there are things that I see that I never could spell if I stopped with the "Z." My alphabet starts where your alphabet ends!

Dr. Seuss,
On Beyond Zebra

stunned by the beauty and elegance of the system described ... Life seemed to be merely a variation on a few simple molecular themes—seemed, for the first time comprehensible, and comprehending it seemed a fascinating intellectual challenge. Never did any time seem more full of wonder and possibility."

As Mr. Blackshaw observes, the world of science—especially biology and medicine—has never seemed more full of wonder and promise. Students at an early age should be exposed to this world, and scientists have a special responsibility to reach out to these students. An example of such a scientist is Dr. Thomas Cech, an Institute investigator at the University of Colorado, who won the Nobel Prize three years ago for his work on RNA. Dr. Cech grew up in Iowa City, Iowa, and recalls discovering science for himself in the fourth grade. He attended Grinnell College and, later, the University of California, Berkeley, where he received his Ph.D. in chemistry. As a faculty member at the University of Colorado, he has made a commitment to teach undergraduates and last year began to teach a freshman chemistry course.

In a lecture, Dr. Cech tells a story written by Dr. Seuss, ***On Beyond Zebra***. Dr. Seuss tells us of young Conrad Cornelius O'Donald O'Dell, his very young friend who is learning to spell. Mr. O'Dell learned the entire alphabet: "A" is for "ape," "B" is for "bear,"... all the way through the 26 letters to "Z" is for "zebra." Mr. O'Dell is very pleased with himself and stops with "Z"—because that is as far as the alphabet goes. Dr. Seuss, however, has a few things to teach young Mr. O'Dell: "You can stop if you want with 'Z,' because most people stop with 'Z.' But not me. In the places I go there are things that I see that I never could spell if I stopped with the 'Z.' My alphabet starts where your alphabet ends!"

For too many children, exposure to science never goes beyond "Z" and the doors to the world of science are never fully opened. But Dr. Seuss gives us hope. At the end of the story, he tells us that he took young Mr. O'Dell to many places to show him new and wonderful things: "I led him around and I tried hard to show, there are things beyond 'Z' that most people don't know. I took him past 'zebra' as far as I could and I think, perhaps, maybe, I did him some good." Dr. Seuss's moral, as it applies here, is that all of us in the world of biology and medicine must do our part to open the doors to all students, particularly women and minority students underrepresented in the sciences, to show them the extraordinary opportunities in biology and medicine and the unlimited potential to benefit all of humankind.

Joseph G. Perpich, M.D., J.D.
Vice President for Grants and
Special Programs

Graduate Science Education

The grants program for graduate education in the biological sciences complements the Institute's programs of biomedical research. Support is provided for the education of students who show strong promise of becoming tomorrow's leading biomedical investigators.

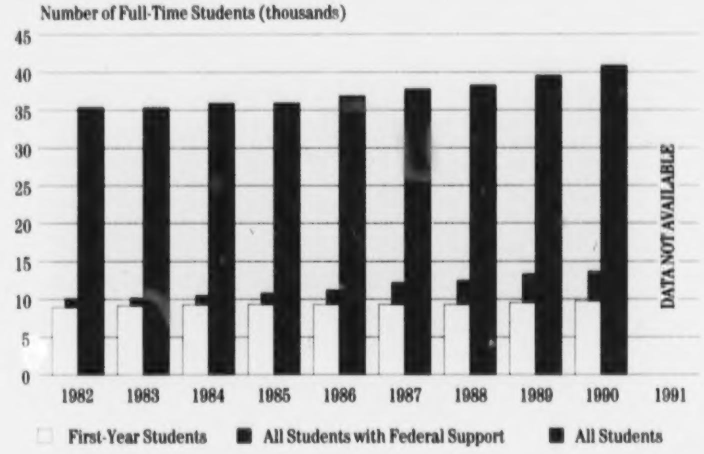
Through its graduate fellowships, the Institute seeks to foster excellence in research and to address unmet national needs. Although projections of the future supply of biomedical scientists vary from one study to another, there seems to be agreement that the number of graduate students from underrepresented minority groups and the number of medically trained investigators engaging in fundamental biomedical research are relatively low and should be significantly increased.

Over the past five years the number of full-time graduate students in the biological sciences at doctorate-granting institutions has increased from about 35,000 to about 40,000 (Figure 2). The number who are U.S. citizens has remained at about 30,000.

The number of Ph.D. degrees awarded in the biological sciences was fairly constant at just under 4,000 until the late 1980's, when the number began to increase (Figure 3). On average, the 4,642 biology Ph.D. recipients in 1991 were registered in graduate school for 6.6 years, an increase of more than one year over the past decade. Women are well represented in the pool of new biology doctorates (38 percent), whereas some minority

Figure 2

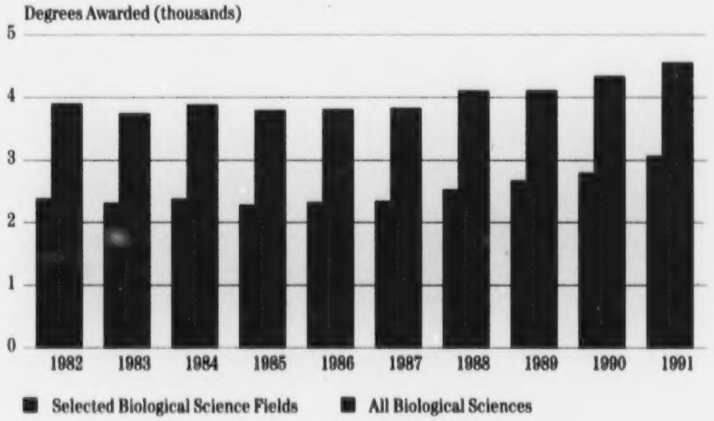
Biological Sciences Graduate Students at Doctorate-Granting Institutions, 1982–1991



SOURCE: National Science Foundation, 1992.

Figure 3

Ph.D. Degrees Awarded in the Biological Sciences, 1982–1991

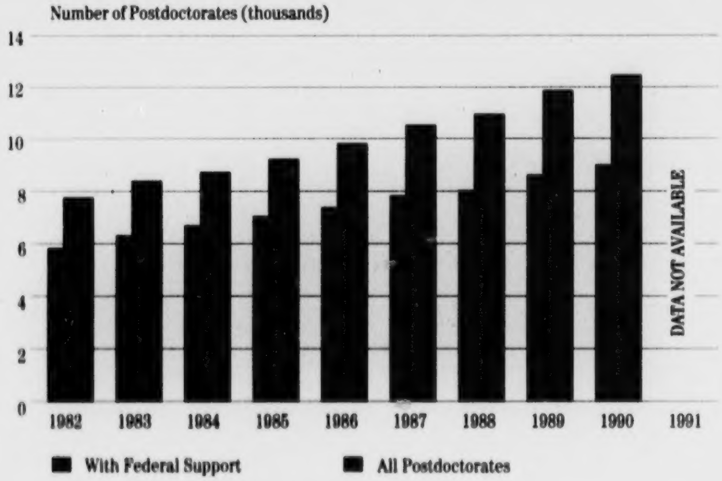


NOTE: Selected fields include those related to the five areas of the Institute's scientific program: cell biology and regulation, genetics, immunology, neuroscience, and structual biology.

SOURCE: National Research Council, Summary Report, Doctorate Recipients from United States Universities, annual.

Figure 4

Biological Sciences Postdoctorates, 1982-1991



SOURCE: National Science Foundation, 1992

groups remain substantially underrepresented (1–2 percent black, 2 percent Hispanic, less than 1 percent Native American).

Universities and the federal government continue to be the major sources of financial support for graduate students (45 percent and 30 percent, respectively). The National Institutes of Health alone accounts for a significant portion of the predoctoral support (6,700 students in 1991) through its training programs. Additional predoctoral support is provided through NIH research grants.

Postdoctoral training is a critical apprenticeship for biomedical investigators (Figure 4), especially for physician-scientists who have not received training in research through pursuit of a Ph.D. degree. In 1991, 72 percent of the new Ph.D.'s in the biological sciences had plans for postdoctoral training. In addition, about 20 percent of new physicians that year had definite plans to seek a research fellowship at some time in the future.

Overview

The graduate education initiative of the Institute grants program is intended to promote excellence, to complement other sources of available support, and to meet special needs. Highlights of the program include the establishment of the Predoctoral Fellowships in Biological Sciences program in 1988 (see the Institute publication *Grants Program Policies and Awards, 1988–*

1989). After five rounds of awards, the Institute now provides over $7.5 million annually to approximately 300 fellows selected under the program. Each fellow is eligible to receive up to five years of support for graduate study in selected biological sciences. Reflecting the maturation of this fellowship program, 16 former predoctoral fellows have notified the Institute that they have successfully defended their Ph.D. theses and have gone on to pursue postdoctoral training at leading laboratories.

The first awards in the **Research Training Fellowships for Medical Students** program were made in 1989 (see the Institute publication *Grants for Science Education, 1989–1990*). These fellowships provide support for one year of full-time research on basic biological processes and disease mechanisms. In 1990 the program was extended so that a limited number of fellows were awarded continued support for either a second year of research or completion of their medical studies (for up to two years). In 1992 $2.2 million was awarded to support 60 medical students in an initial research year and 41 fellows in continued fellowship activities, either a second year of research or study toward the M.D. degree. A total of $6.3 million has been awarded under this program since its inception in 1989.

The 1989 medical student fellows reported on their year of fellowship research at the first Scientific Meeting of Fellows in May 1990. Since then, the fellows have met annually in Bethesda to present the results of their work (see the 1991 and 1992 editions of the Institute publication *Scientific Meeting of Fellows, Research Training Fellowships for Medical Students, Program and Abstracts*).

The Institute began a third program of fellowship awards in 1990, the **Postdoctoral Research Fellowships for Physicians**, to help increase the supply of well-trained physician-scientists. The fellowships provide three years of support for training in biomedical research to physicians who have completed at least two years of postgraduate clinical training (see *Grants for Science Education, 1990–1991*). Since the first competition, more than $3.5 million has been awarded to 49 men and women who are working at the leading edge of their area of research under the guidance of superb mentors.

The first meeting of predoctoral and physician research fellows is scheduled for June 1993. Recipients of Predoctoral Fellowships in Biological Sciences and Postdoctoral Research Fellowships for Physicians will be convened at the new Institute headquarters in Chevy Chase, Maryland, to share their research findings with other fellows and colleagues in poster and oral presentations.

The Research Resources program has been another avenue for support of graduate education. The first grants under this initiative, in 1987 and 1988, went to Cold Spring Harbor, Jackson, and Marine Biological Laboratories. These three grants and a second grant to Cold Spring Harbor, together totaling $14 million, were awarded, in part, to support the laboratories' unique series of short courses for biomedical scientists.

Figure 5

Predoctoral Fellowships in Biological Sciences Program and Award Highlights

Fellowship Terms

- 66 awards annually
- Up to five years of support
- $25,700 annually
    - $14,000 stipend
    - $11,700 cost-of-education allowance*

Eligibility

- Less than one year of graduate study completed
- Full-time study toward a Ph.D. or Sc.D. degree
- Selected biological sciences
    - biochemistry
    - biophysics
    - biostatistics
    - cell biology and regulation
    - developmental biology
    - epidemiology
    - genetics
    - immunology
    - mathematical biology
    - microbiology
    - molecular biology
    - neuroscience
    - pharmacology
    - physiology
    - structural biology
    - virology

1992 Predoctoral Fellows

- Total number: 70
    - 35 women and 35 men
    - 61 U.S. citizens and 9 foreign citizens
    - 37 college seniors (at the time of fellowship application) and 33 graduate students, including 3 medical students
    - 9 minorities underrepresented in the sciences

Fellowship institutions: 23

All Current Predoctoral Fellows

- Total number: 294
    - 112 women and 182 men
    - 251 U.S. citizens and 43 foreign citizens
    - 128 college seniors (at the time of application) and 166 graduate students, including 28 medical students, 2 physicians and 3 veterinarians
    - 31 minorities underrepresented in the sciences
- Fellowship institutions: 51
- Distribution by field
    - 55 biochemistry and structural biology
    - 5 biostatistics, epidemiology, and mathematical biology
    - 49 cell biology and immunology
    - 99 genetics, microbiology, molecular biology, and virology
    - 86 neuroscience, biophysics, developmental biology, pharmacology, and physiology

** Effective June 1993, the annual cost-of-education allowance will increase to $12,700.*

Predoctoral Fellowships in Biological Sciences

The goal of the Institute's Predoctoral Fellowships in Biological Sciences program is to promote excellence in biomedical research by helping researchers of exceptional promise to obtain high-quality graduate education. Fellows must pursue a full-time graduate program leading to the Ph.D. or Sc.D. degree.

Predoctoral fellowships are intended for students at or near the beginning of their graduate study toward a Ph.D. or Sc.D. in any of 16 eligible fields in the biological sciences. In general, these areas of fundamental research parallel those of the Institute's scientific program.

College seniors, college graduates with limited or no postbaccalaureate graduate study in the biological sciences, or first-year graduate students may apply for predoctoral fellowships. Individuals who hold or are pursuing medical or dental degrees (M.D., D.O., D.V.M., or D.D.S.) may also apply, if they meet eligibility criteria.

The predoctoral fellowship program is open to applicants from any country. Fellows who are U.S. citizens or nationals may study in the

Figure 6

1992 Predoctoral Fellows–Educational Origins

Undergraduate Institutions

Auburn University
Brown University, 4
California Institute of Technology
California State University–Hayward
Case Western Reserve University
City University of New York Hunter College
College of St. Elizabeth
Colorado State University
Cornell University
Drew University
Duke University
Earlham College
Florida International University
Harvard University, 10
Indiana University at Bloomington
Johns Hopkins University, 2
Marquette University
McGill University, Canada
Michigan State University
Northwestern College
Pennsylvania State University
Princeton University, 4
Queen's University, Canada
Rice University
Rutgers the State University of New Jersey, New Brunswick Campus, 2
Simon Fraser University, Canada
Stanford University, 3
Tel Aviv University, Israel
Texas Tech University
University of California–Berkeley, 2
University of California–Davis
University of California–Los Angeles
University of California–San Diego
University of Cambridge, England, 2
University of Chicago
University of Connecticut
University of Florida
University of Maryland College Park
University of Miami
University of Minnesota–Twin Cities
University of Texas at Austin, 2
University of Toronto, Canada
University of Washington
University of Wisconsin–Madison
Wellesley College
Williams College
Yale University, 2

High Schools

Arizona
Marcos de Niza, Tempe
California
Artesia, Artesia
Bishop Montgomery, Torrance
John Marshall, Los Angeles
Mt. Carmel, San Diego
Oakmont, Roseville
Palisades, Pacific Palisades
Palo Alto, Palo Alto
Colorado
Mullen, Denver
Rocky Ford, Rocky Ford
Connecticut
Masuk, Monroe
Shelton, Shelton
District of Columbia
Maret
Florida
Father Lopez, Daytona Beach
Leto, Tampa
Our Lady of Lourdes, Miami
Pine Crest, Ft. Lauderdale
Illinois
Deerfield, Deerfield
New Trier, Winnetka
Iowa
Unity Christian, Orange City
Kentucky
Madison Central, Richmond
Maryland
CES Jewish Day, Rockville
Dulaney Senior, Timonium
The German School, Potomac
Paint Branch, Burtonsville
Walt Whitman, Bethesda
Winston Churchill, Potomac
Massachusetts
Dartmouth, North Dartmouth
Phillips Academy, Andover
Reading Memorial, Reading
Weston, Weston
Michigan
Clawson, Clawson
Troy, Troy
Minnesota
Duluth East, Duluth
New Jersey
A.L. Johnson Regional, Clark
De Paul Diocesan, Wayne
Dwight–Englewood, Englewood
Hanover Park, East Hanover
Hightstown, Hightstown
Middletown South, Middletown
Millburn, Millburn
New York
Bronx High School of Sciences, New York City
The Dalton School, New York City
Fieldston, New York City
Hackley, Tarrytown
Ithaca, Ithaca
North Dakota
Fargo North, Fargo
Ohio
Lexington, Lexington
University, Chagrin Falls
Oregon
Crescent Valley, Corvallis
Pennsylvania
Lower Merion, Ardmore
Selinsgrove Area, Selinsgrove
Texas
A&M Consolidated, College Station
Bellaire, Bellaire
Lufkin, Lufkin
Randolph, Universal City
Virginia
Osbourn Park, Manassas
Woodberry Forest, Woodberry Forest
Wisconsin
Menomenee Falls, Menomenee Falls
Pope Pius XI, Milwaukee
Outside the United States
Baleares International, San Agustin, Baleares, Spain
Ben–Zvi, Kiryat–Ono, Israel
Cariboo Hill, Vancouver, British Columbia, Canada
Centennial Regional, Greenfield Park, Quebec, Canada
Confederation, Nepaen, Ontario, Canada
George S. Henry, North York, Ontario, Canada
Hillhead, Glasgow, United Kingdom
International School, Bangkok, Thailand
St. Xavier's, Ahmedabad, Gujarat, India
Waterloo Collegiate Institution, Waterloo, Ontario, Canada

Figure 7

Predoctoral Fellowships in Biological Sciences Fellowship Institutions, 1988-1992

Albert Einstein College of Medicine
Baylor College of Medicine
Boston University
Brandeis University
Brown University
California Institute of Technology
Carnegie Mellon University
Case Western Reserve University
Columbia University
Cornell University
Cornell University Medical Center
Duke University
Emory University
Harvard University
Johns Hopkins University
Massachusetts Institute of Technology
McGill University, Canada
Northwestern University
Princeton University
Purdue University
Rockefeller University
Rush University
Rutgers the State University of New Jersey New Brunswick Campus
Stanford University
Tufts University School of Medicine
Tulane University
University of California–Berkeley
University of California–Irvine
University of California–Los Angeles
University of California–San Diego
University of California–San Francisco
University of Cambridge, England
University of Chicago
University of Colorado, Boulder
University of Colorado Health Sciences Center
University of Connecticut
University of Florida
University of Illinois at Urbana/Champaign
University of Maryland at Baltimore
University of Massachusetts at Worcester
University of Michigan–Ann Arbor
University of Minnesota–Twin Cities
University of New Mexico Main Campus
University of North Carolina at Chapel Hill
University of Oregon
University of Oxford, England
University of Pennsylvania
University of Tennessee, Memphis
University of Texas Medical Branch at Galveston
University of Texas Southwestern Medical Center at Dallas
University of Utah
University of Virginia
University of Washington
University of Wisconsin–Madison
Washington University
Yale University

United States or abroad; fellows who are foreign citizens or nationals may only study at U.S. institutions.

The National Research Council of the National Academy of Sciences conducts the predoctoral fellowship competition on behalf of the Institute. For the 1992 competition, panels of biomedical scientists evaluated nearly 1,400 applications, paying particular attention to each applicant's reference letters, plan of study and research, and previous research experience, in addition to quantitative indicators such as Graduate Record Examination scores and undergraduate grade point average. Based on the panel review, awards were made to applicants who had demonstrated superior scholarship and showed the greatest promise for future achievement in biomedical research (Figure 5).

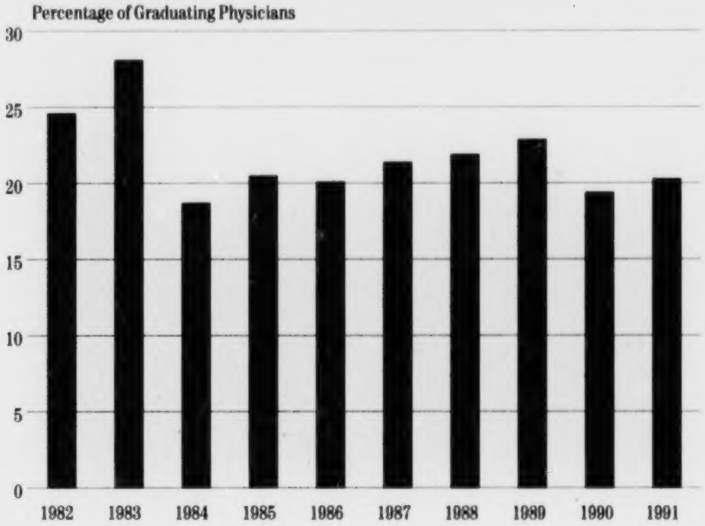
Following a review of the panel's recommendations, the Institute selected 35 men and 35 women as fellows. Among these fellows are three from Canada and one each from England, India, Iran, Israel, the Philippines, and Spain. Nine outstanding students from minority groups underrepresented in the sciences are included in this year's group, bringing to 31 the current number of black, Hispanic, Native American, and Native Pacific Islander predoctoral fellows. The fellows selected for this year studied at 47 undergraduate institutions, including 6 abroad. These fellows intend to undertake their graduate studies at 23 educational institu-

Predoctoral Fellowships in Biological Sciences—1992 Fellows

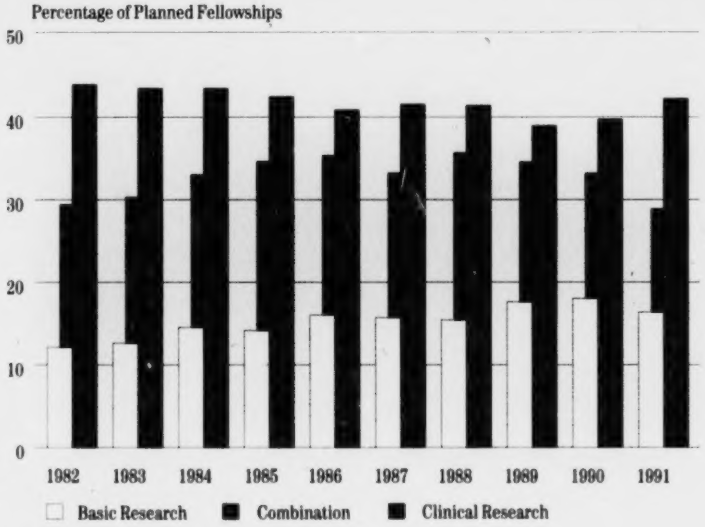
Name	Fellowship Institution	Department
Biochemistry and Structural Biology		
David Min Chao	Massachusetts Institute of Technology	Biology
Melinda Bonnie Fagan	Stanford University	Biological Sciences
David Henry Hackos	University of California–San Francisco	Biophysics
Stuart Spencer Licht	Massachusetts Institute of Technology	Chemistry
I-Fan Theodore Mau	University of California —San Francisco	Biophysics
Kayvan Roayaie	University of California —San Francisco	Biochemistry
Jennifer Ellen Schmidt	University of Washington	Biochemistry
Kyle John Vogan	McGill University, Canada	Biochemistry
Edgar Chong Young	Brandeis University	Biochemistry
Karen Marie Zito	University of California—Berkeley	Molecular and Cell Biology
Biostatistics, Epidemiology, and Mathematical Biology		
Anne M. Bronikowski	University of Chicago	Evolutionary Biology
Michael Joseph Daniels	Harvard University	Biostatistics, Cell Biology and Immunology
Jose Antonio Alcantara	University of Pennsylvania	Biology
Lara Jane Ausubel	Harvard University	Medical Sciences
Michelle Leigh Boytim	Stanford University	Immunology
Bradley Brian Brasher	Harvard University	Medical Sciences
George Yen-Hsi Liu	University of Cambridge, England	Immunology
Ellen Annette Lumpkin	University of Texas Southwestern Medical Center at Dallas	Cell and Molecular Biology
Thomas Nicholas Moreno	University of California—San Diego	Biology
Helen Chun-Hui Su	Brown University	Biology and Medicine
Jennifer Jo Wernegreen	Yale University	Biology
Carol Norris White	University of Connecticut	Molecular and Cell Biology
Genetics, Microbiology, Molecular Biology, and Virology		
Adam Henry Amsterdam	Massachusetts Institute of Technology	Biology
Kristin Kay Baldwin	Stanford University	Combined Admissions Mode
Hsiuchen Chen	Harvard University	Medical Sciences
John Shichieh Chuang	University of California —San Francisco	Biochemistry and Biophysics
Francesca Cole	Massachusetts Institute of Technology	Biology
Gene Cutler	University of California—Berkeley	Molecular and Cell Biology
Judith Kimberly Davie	University of California—Berkeley	Molecular and Cell Biology
Arshad Bachubhai Desai	University of California —San Francisco	Biochemistry and Biophysics
Douglas David Fenger	Massachusetts Institute of Technology	Biology
Michael Jonathan Ford	Cornell University	Genetics and Development
Kenneth Adam Frauwirth	University of California—Berkeley	Molecular and Cell Biology
Laura Susan Gammill	Massachusetts Institute of Technology	Biology
Tracy Lanise Johnson	University of California—Berkeley	Molecular and Cell Biology
Olivia Guadalupe Kelly	Harvard University	Biochemistry, Molecular, Cell, and Developmental Biology
Corwin Francis Kostrub	Harvard University	Medical Sciences
Mark Mordecai Metzstein	Massachusetts Institute of Technology	Biology
Anh Tuan Nguyen-Huynh	Harvard University	Medical Sciences
Allison Joy Oppenheimer	Harvard University	Medical Sciences
Robin Rae Pals	Northwestern University	Cell and Molecular Biology
Adam Daniel Rudner	University of California —San Francisco	Biochemistry and Biophysics
Linda April Stillman	University of Chicago	Molecular Genetics and Cell Biology
Christian J. Ullsperger	University of California—Berkeley	Molecular and Cell Biology
Leticia Rosa Vega	Massachusetts Institute of Technology	Biology
Sonya Marie Vieira	Johns Hopkins University	Human Genetics
Diana Elaine Wofford	University of California—San Diego	Biology
Neuroscience, Biophysics, Developmental Biology, Pharmacology, and Physiology		
Michael Stephen Beauchamp	University of California—San Diego	Neurosciences
Mark Christopher Bieda	Stanford University	Neuroscience
Solange Pezon Brown	Harvard University	Medical Sciences
Jennifer Arwen Cummings	University of California —San Francisco	Neuroscience
Hannah Alice Dvorak	California Institute of Technology	Biology
Eva Marie Finney	University of California—Berkeley	Molecular and Cell Biology
Joanne Fraher	University of Pennsylvania	Biomedical Graduate Studies
Yuval Gazit	Massachusetts Institute of Technology	Health Sciences
Takao Kurt Hensch	University of California —San Francisco	Neuroscience
Anton Edward Krukowski	University of California —San Francisco	Biophysics
Matthew Swan Lawrence	Stanford University	Biology
Jennifer Fran Linden	California Institute of Technology	Computation and Neural Systems
Henry Wiltshire Mahncke	University of California —San Francisco	Neurosciences
Jennifer Ann Martino	Rutgers the State University of New Jersey New Brunswick Campus	Chemistry
Mireya Nadal-Vicens	Stanford University	Neurosciences
Rhett Valino Pascual	University of California—Berkeley	Molecular and Cell Biology
Deborah Melissa Redish	Massachusetts Institute of Technology	Biology
Naomi Leah Ruff	University of California—San Diego	Neurosciences
Chris Schafmeister	University of California —San Francisco	Biophysics
Christine Theresia Schulteis	University of California—Los Angeles	Neuroscience
Martin Bernard Stemmler	California Institute of Technology	Computation and Neural Systems
Ramon Kenneth Tabtiang	University of California—San Francisco	Biochemistry
Jennifer Wahlsten	University of Minnesota—Twin Cities	Cell and Developmental Biology

Figure 8

M.D. Plans at Graduation, 1982-1991
Intention to Seek a Research Fellowship



Research Interests



SOURCE: AAMC Graduation Questionnaire, *annual.*

Note: *The questionnaire allowed for an "undecided" response for the first time in 1984, which may account for the abrupt drop between 1983 and 1984 of intended research fellowships (top graph).*

tions in the United States and abroad (Figure 6).

The Institute's decision to invest in graduate education was motivated, in part, to encourage diversity among students pursuing full-time studies toward a doctorate in the biological sciences. If current trends continue in future fellowship competitions, about 10 to 15 percent of the fellows will be from minority groups underrepresented in the sciences, and about 40 to 45 percent will be women.

The Institute will continue to award about 66 new predoctoral fellowships annually. At present 294 predoctoral fellows are receiving support at 51 academic institutions, at an annual cost of over $7.5 million (Figure 7). The predoctoral fellows selected in the 1988–1991 competitions continue to demonstrate exceptional ability as biomedical researchers. They have notified the Institute of 68 publications in peer-reviewed journals during the past year, based on fellowship research, and of 76 poster and 34 oral presentations at international, national, and regional scientific meetings. In addition, 16 fellows have reported to the Institute that they have completed their graduate studies and defended their theses.

Research Training Fellowships for Medical Students

The primary goal of the Institute's Research Training Fellowships for Medical Students is to increase the proportion of physicians who pursue careers with significant involvement in research. The fellowships provide support for an intensive year of laboratory investigation for medical students who have begun to consider research as a part of their future career.

The pool of potential physician-scientists is drawn from current medical school students with a keen interest in research. The Association of American Medical Colleges annually surveys all students receiving an M.D. degree in a given year. According to the latest graduation questionnaires, about half the M.D. recipients had participated in research projects in medical school, and one-third were coauthors of a published paper. Further, among the one-fifth of the graduating medical students who intend to seek a research fellowship, the percentage planning to focus on basic science, either alone or combined with clinical research, remains fairly steady.

The AAMC also reports that about 13 percent of M.D. graduates expect to be significantly involved in research in their careers (Figure 8). However, less than 1 percent want a full-time academic career with a focus on basic science. These trends highlight the continuing importance of nurturing medical stu-

Figure 9

Research Training Fellowships for Medical Students Program and Award Highlights

Initial Award Terms

- Up to 60 awards annually
- One year of support
- $21,700 fellowship for 1991
  - $14,000 stipend
  - $4,000 research allowance*
  - $3,700 institutional allowance*
- Continued awards possible for a second year of research
- Continued awards possible for up to two years while completing medical school

Continued Awards Terms

- Second Year of Research ($21,700 for one year)
  - $14,000 stipend
  - $4,000 research allowance*
  - $3,700 institutional allowance*
- Return to Medical Studies ($25,700 annually for up to two years)
  - $14,000 annual stipend
  - $11,700 educational allowance*

Eligibility for Initial Awards

- Currently enrolled in a U.S. medical school
- Fundamental research (basic biological processes and disease mechanisms)
- Full-time research
- Fellowship year at any academic or not-for-profit research institution in the United States, except NIH
- Not enrolled in an M.D./Ph.D. or Ph.D. program

All Current Medical Student Fellows

Initial Awards

- Total number: 60
  - 27 women and 33 men, 5 minorities underrepresented in the sciences
  - Medical school level completed
  - Year 1: 2 fellows
  - Year 2: 36 fellows
  - Year 3: 20 fellows
  - Year 4: 2 fellows

Continued Awards: Research

- Total number: 4
  - 3 women and 1 man, 1 minority underrepresented in the sciences
  - Medical school level completed
  - Year 2: 1 fellow
  - Year 3: 1 fellow
  - Year 4: 2 fellows

Continued Awards: Return to Medical Studies

- Total number: 37**
  - 12 women and 25 men, 6 minorities underrepresented in the sciences
  - Current medical school level
  - Year 3: 17 fellows
  - Year 4: 20 fellows

** Effective June 1993, the research allowance will be increased to $4,500, the institutional allowance will be increased to $4,700, and the educational allowance will be increased to $12,700.*

*** These figures include 12 medical student fellows and 10 HHMI-NIH Research Scholars selected for continued fellowship awards in 1992. In addition, 15 of the continued fellows who were selected last year are in the second year of such support.*

Figure 10

1992 Medical Student Fellows (Initial Awards) Educational Origins

Undergraduate Institutions

- Amherst College, 2
- Boston College
- Boston University
- Bradley University
- Brown University, 6
- Bryn Mawr College
- Cornell University, 4
- Duke University, 4
- Emory University
- Harvard University, 4
- Haverford College
- Massachusetts Institute of Technology, 2
- Michigan State University
- Pennsylvania State University
- Princeton University, 2
- Rutgers, the State University of New Jersey, New Brunswick Campus
- Santa Clara University
- Stanford University, 2
- Tufts University
- University of Arizona–Tucson
- University of California–Berkeley, 2
- University of California–San Diego
- University of Iowa
- University of Michigan–Ann Arbor, 2
- University of North Carolina at Chapel Hill, 2
- University of Nebraska–Lincoln
- University of Pennsylvania, 3
- University of Rochester
- University of Toledo
- University of Vermont
- University of Virginia
- University of Washington
- Washington University
- Wilkes University
- Yale University, 3

High Schools

Alabama
- Mountain Brook, Birmingham

California
- Cate School, Carpinteria
- Cornvallis, Los Angeles
- Los Altos, Los Altos
- Oak Grove, San Jose
- St. Rose Academy, San Francisco
- The York School, Monterey

Connecticut
- New Fairfield, New Fairfield

Florida
- Winter Park, Winter Park

Illinois
- Guilford, Rockford
- Perkin Community, Peoria

Indiana
- Carmel, Carmel

Iowa
- West, Iowa City

Kansas
- Shawnee Heights, Tecumseh

Maryland
- Deerfield Academy, Deerfield
- Gaithersburg, Gaithersburg
- Garrison Forest School, Garrison
- Meade, Fort Meade
- Montgomery Blair, Silver Spring

Massachusetts
- Wachusett Regional, Holden

Michigan
- Ann Arbor Huron, Ann Arbor
- Belding Area, Belding
- Rochester Adams, Rochester
- West Bloomfield, Bloomfield

Minnesota
- Fosston, Fosston

Nebraska
- Papillion—La Vista, Papillion

New Hampshire
- Phillips Exeter Academy, Exeter, 2

New Jersey
- Hopewell Valley, Pennington
- Moorestown Public, Moorestown
- Northern Valley Regional, Demarest
- Union Catholic Regional, Scotch Plains

New York
- Bronx High School of Science, New York City
- Clarence, Clarence
- Honeoye Falls—Lima, Honeoye Falls
- Horace Mann, Bronx
- Manhasset Public, Manhasset
- Roslyn, Roslyn
- Sachem, Lake Ronkonkoma
- St. Francis Preparatory, Fresh Meadows
- Stuyvesant, New York City, 2
- West Hempstead, West Hempstead, 2

North Carolina
- Charles E. Jordan, Durham
- East Mecklenberg, Charlotte
- Fayetteville Academy, Elizabethtown
- North Carolina School of Science and Math, Durham
- Page, Greensboro

Ohio
- Greenhills, Cincinnati
- Sylvania Southview, Sylvania

Pennsylvania
- Pittston Area, Pittston
- Shady Side Academy, Pittsburgh
- Wyoming Area, Exeter

Texas
- Skyline, Dallas

Virginia
- The Collegiate Schools, Richmond

Washington
- Bellingham, Bellingham

Wisconsin
- University School of Milwaukee, Milwaukee

Outside the United States
- Anglo Chinese School, Singapore
- Eberhard-Karls, Tuebingen, Germany

dent interest and providing training opportunities in fundamental research.

For the last six years, the Research Scholars Program, sponsored jointly by the Institute and NIH, has brought selected medical students to the NIH intramural laboratories for a year of fundamental research experience. To increase the number of students who may benefit from a similar experience, the Research Training Fellowships for Medical Students were instituted. These fellowships also provide support for a year of full-time research. Fellows may affiliate with a laboratory at any academic or not-for-profit research institution in the United States (except NIH), thus complementing the HHMI-NIH program.

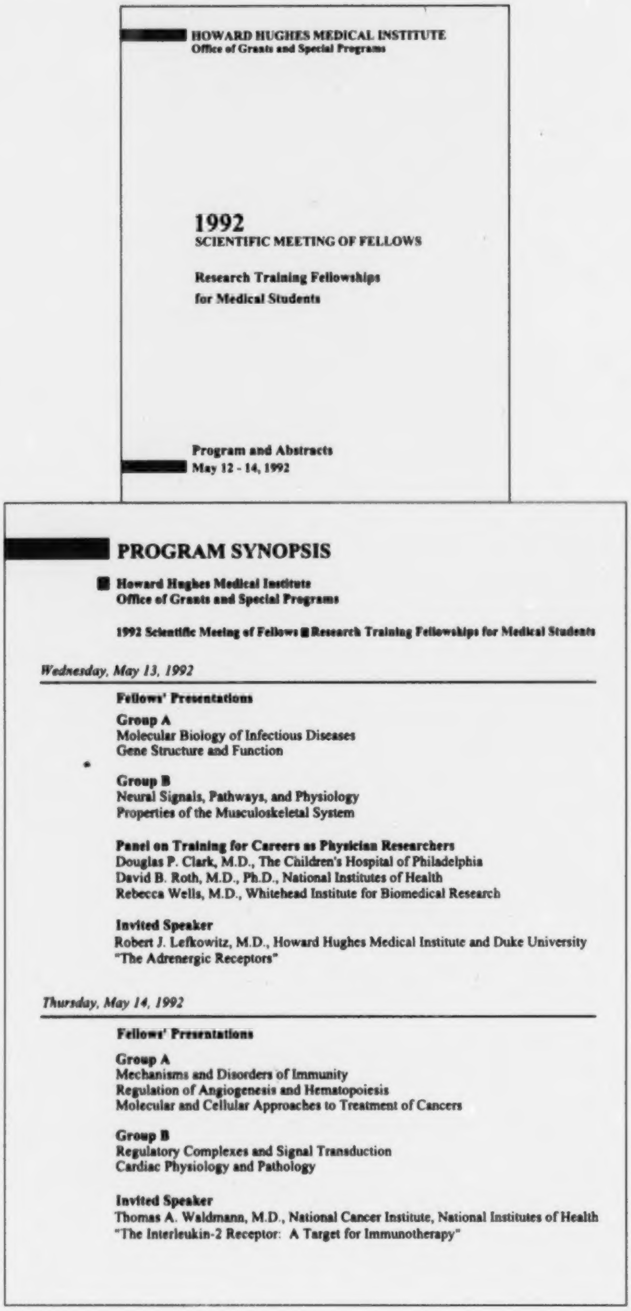
Initial Year of Research

Research Training Fellowships for Medical Students are awarded to applicants who show the greatest promise of achievement in biomedical research and who have demonstrated superior scholarship as undergraduates and during their initial medical school training (Figure 9). Applicants must be enrolled in a medical school in the United States. A panel of biomedical scientists convened by the Institute evaluates each application, placing special emphasis on the letters of reference, the proposed research plan, and the mentor's plans for training the prospective fellow.

The 1992 competition resulted in awards to 60 new fellows, including

Figure 11

1992 Scientific Meeting of Fellows, Program



HOWARD HUGHES MEDICAL INSTITUTE
Office of Grants and Special Programs

1992
SCIENTIFIC MEETING OF FELLOWS

Research Training Fellowships
for Medical Students

Program and Abstracts
May 12 - 14, 1992

PROGRAM SYNOPSIS

Howard Hughes Medical Institute
Office of Grants and Special Programs

1992 Scientific Meeting of Fellows ■ Research Training Fellowships for Medical Students

Wednesday, May 13, 1992

Fellows' Presentations

Group A
Molecular Biology of Infectious Diseases
Gene Structure and Function

Group B
Neural Signals, Pathways, and Physiology
Properties of the Musculoskeletal System

Panel on Training for Careers as Physician Researchers
Douglas P. Clark, M.D., The Children's Hospital of Philadelphia
David B. Roth, M.D., Ph.D., National Institutes of Health
Rebecca Wells, M.D., Whitehead Institute for Biomedical Research

Invited Speaker
Robert J. Lefkowitz, M.D., Howard Hughes Medical Institute and Duke University
"The Adrenergic Receptors"

Thursday, May 14, 1992

Fellows' Presentations

Group A
Mechanisms and Disorders of Immunity
Regulation of Angiogenesis and Hematopoiesis
Molecular and Cellular Approaches to Treatment of Cancers

Group B
Regulatory Complexes and Signal Transduction
Cardiac Physiology and Pathology

Invited Speaker
Thomas A. Waldmann, M.D., National Cancer Institute, National Institutes of Health
"The Interleukin-2 Receptor: A Target for Immunotherapy"

Figure 12

Research Opportunities for Medical Students

The Howard Hughes Medical Institute has two programs that provide opportunities for medical students in the United States to spend a year doing intensive research. For each program, the students are selected on the basis of a national competition. STUDENTS MAY APPLY TO ONLY ONE OF THESE PROGRAMS. A comparison of the two programs follows.

	HHMI-NIH Research Scholars Program (Cloister Program)	**HHMI Research Training Fellowships for Medical Students Program**
Time	Appointment is for nine months to one year, with an opportunity for some scholars to extend for an additional year of research.	The fellowship term is one year, with an opportunity for some fellows to extend for an additional year of research.
Place	Research is conducted at NIH in Bethesda, Md. The Cloister, a residential facility for scholars, is available on the NIH campus. Travel to and from Bethesda is provided.	Research is conducted at an academic or not-for-profit research institution in the United States chosen by the fellow. Research may not be at NIH.
Salary/Stipend	The annual salary for scholars is $16,800. Research scholars are employees of HHMI with fringe benefits.	The annual stipend for fellows is $14,000. Fellows are not HHMI employees and receive no fringe benefits. However, a portion of the $4,700 allowance to the fellowship institution may be used for health insurance for the fellow.
Research Topic	The research project is selected upon arrival at NIH, after a round of laboratory visits.	The research project must be described in the fellowship application.
Research Costs	There is no special research allowance. Costs are covered by the scholar's laboratory.	A $4,500 research allowance on behalf of the fellow is provided to the fellowship institution, in addition to the $4,700 institutional allowance.
Citizenship	Scholars must be citizens or permanent residents of the United States.	There are no citizenship requirements. However, applicants must be attending medical school in the United States.
Medical School Support	Students from each program may compete for a small number of awards for up to two additional years of fellowship support while completing medical school. The support will be a $14,000 annual stipend and a $12,700 annual allowance toward tuition and other education-related expenses.	
For Information and Applications:	HHMI-NIH Research Scholars Program Howard Hughes Medical Institute 1 Cloister Court Bethesda, MD 20814-1460 (301) 951-6710 or (800) 424-9924	Research Training Fellowships for Medical Students Howard Hughes Medical Institute Office of Grants and Special Programs/MED 6701 Rockledge Drive Bethesda, MD 20817 (301) 571-8412

33 men and 27 women, for one year of full-time laboratory research (Figure 10). These fellows are enrolled in medical school at 18 institutions and are graduates of 35 colleges and universities. Six of the fellows will be in a laboratory not affiliated with their medical school.

By the end of June of the fellowship year, papers by 11 of the fellows selected in the 1991 competition had been accepted for publication in peer-reviewed journals. The medical student fellows were convened in Bethesda at a May 1992 Scientific Meeting of Fellows (Figure 11), which provided further evidence of their productive year and their enthusiasm for continued involvement in fundamental science (see the Institute publication ***1992 Scientific Meeting of Fellows, Research Training Fellowships for Medical Students, Program and Abstracts***). Several of the fellows reported that discussing probing questions about their work with their peers and the invited guests at the meeting, presenting their fellowship research results, and hearing about the other fellows' research year were highlights of their fellowship experience. They also remarked on the camaraderie that developed among the fellows during the course of the meeting.

Continued Support

Fellows may apply for support for a second year of research. They may also compete for continued fellowship support for up to two years while they complete their study toward the M.D. degree. Medical students at NIH under the auspices of the HHMI-NIH Research Scholars Program are also eligible to apply for this continued fellowship support toward completion of medical studies (Figure 12; see page 106 for new address and phone number).

Candidates for continued fellowship support in 1992 were evaluated on the basis of their demonstrated ability during the research year, their promise for future achievement in biomedical research, and their career intentions, including any plans for additional research training after completion of medical school. Four fellows were awarded support for a second year of fellowship research. In addition, 22 fellows and research scholars were selected for up to two years of fellowship support while completing medical school. These new awards bring to 37 the number of continued fellows currently supported in their studies toward medical degrees.

Assessment

As part of the coordinated series of grants program assessment activities, the Institute is continuing the long-term tracking of the education and careers of the medical student fellows and research scholars. Of special interest will be the students' continued involvement in research and pursuit of further training, either toward the Ph.D. degree or in postdoctoral positions. By the end of the initial fellowship year, two of the 1991 fellows reported plans to enroll in a Ph.D. or joint degree pro-

Research Training Fellowships for Medical Students—1992 Fellows

Initial Awards—First Year of Research

Biochemistry and Structural Biology

Name	Fellowship Institution	Research Mentor	Department
Andrew C. Hecht The elucidation of the mechanism of action of a novel catabolic factor synthesized by chondrocytes	Harvard University	Benjamin V. Treadwell, Ph.D.	Orthopedic Surgery
Michael George Jacoby IV NMR studies of albumin transport function in diabetes mellitus	Washington University	David P. Cistola, M.D., Ph.D.	Biochemistry
Cindy Levine Molecular aspects of endothelial cell modulation of arterial cholesterol trafficking	Cornell University Medical Center	David Hajjar, Ph.D.	Biochemistry
Melinda Aileen Maggard Characterizing the receptor of Mullerian Inhibiting Substance, a fetal inhibitor protein	Harvard University	Patricia K. Donahoe, M.D.	Pediatric Surgery

Biostatistics, Epidemiology, and Mathematical Biology

Name	Fellowship Institution	Research Mentor	Department
Kenneth Charles Goldberg Examination of small area variation in medical practice using detailed clinical information	Medical College of Wisconsin	Arthur Hartz, M.D., Ph.D.	Biostatistics

Cell Biology and Immunology

Name	Fellowship Institution	Research Mentor	Department
Peter Alan Barton Homozygous C5 deficiency in the endotoxin-triggered shock response	University of Michigan–Ann Arbor	Jeffrey S. Warren, M.D.	Pathology
Tamara Nathan Block Characterization of the T-cell response in autoimmune diabetes	University of Chicago	Kevan C. Herold, M.D.	Medicine
Judson Michael Brandeis The mechanism of oral tolerance	Harvard University (Vanderbilt University)*	Charles B. Carpenter, M.D.	Medicine
Brian Eugene Brigman Assessing the role of fibronectin in the modulation of synovial rheology	University of North Carolina at Chapel Hill	Larry Benowitz, Ph.D.	Neurosurgery
Christopher Hayden Cabell Creation of MARCKS deficient cells	Duke University	Perry J. Blackshear, M.D.	Medicine
John Dwight Chen Determining the antigenic domain of anchoring fibril (Type VII) collagen	Stanford University	David T. Woodley, M.D.	Dermatology
Briggs Edward Cook Survival and differentiation of retinal precursor cells following terminal mitosis	Johns Hopkins University	Rubin Adler, M.D.	Ophthalmology/Neuroscience
Michael Jay Fisher Role of the erythropoietin receptor in human erythroleukemia and diamond-blackfan anemia	Harvard University	Alan D. D'Andrea, M.D.	Pediatric Oncology
Tony Friedman A murine model for ADA deficiency: immune system development and function	Duke University	Mary Louise Markert, M.D., Ph.D.	Pediatrics
Tejal Kanti Gandhi Cell adhesion mechanisms that regulate tumor metastasis	Harvard University	Bruce Zetter, Ph.D.	Surgery
Robert Ronald Hergan, Jr. Establishment of antigen presenting function in tumor cells	University of Pennsylvania	William Ming Fu Lee, M.D. Ph.D.	Medicine
Jennifer Lynn Hunter Breast cancer: the function of the p53 protein	Duke University	James Dirk Iglehart, M.D.	Surgery
Rainu Kaushal Study of a recently cloned novel protein in the mediation of argiogenesis and tumorigenesis	Harvard University	Judah Folkman, M.D.	Surgery
Sunjay Kaushal Functional analysis of MEF2, transcriptional factors of cardiac myosin heavy chain gene expression	Harvard University (Johns Hopkins University)*	Vijak Mahdavi, Ph.D.	Cardiology
Daniel Lewis Kraft A study of human T-cell differentiation in the SCID-hu mouse	Stanford University	Irving L. Weissman, M.D.	Pathology
Phillip R. Kravetz A herpes based vector for cell-specific gene delivery and expression	Harvard University (University of Michigan—Ann Arbor)*	Arthur B. Pardee, Ph.D.	Molecular Pharmacology
Katherine Paige Lemon The role of MAP-kinases and RSK in T cell activation and response to immunosuppressants	Harvard University	John Blenis, Ph.D.	Cellular and Molecular Physiology
Steven P. Leon Expression and function of the *c-sis* oncogene in nonfunctioning pituitary adenomas	Harvard University	Peter McL. Black, M.D., Ph.D.	Neurosurgery
James M. Malone The effects of cytokines on MHC class I expression and the development of tumor-specific immunity	University of Nebraska Medical Center	Peter Kolbeck	M.D., Pathology
Ryland Melford The resting properties of identified nociceptive neurons	Washington University	Edwin McCleskey, Ph.D.	Cell Biology and Physiology
Michael E. Mitchell The regulation of arginine transport in cytokine stimulated macrophages	Harvard University	James Cunningham, M.D.	Hematology
John Edwin Monks Optimization of neutralizing activities against HIV	Duke University	Dani P. Bolognesi, Ph.D.	Surgery/Microbiology/ Immunology
Sam Peyvand Mostafapour Molecular determinants of 2 adrenergic receptor	Stanford University	Brian Kobilka, M.D.	Molecular and Cell Physiology
George Braxton Payne Investigation *in vitro* of c-myc transcriptional control by a mechanism of elongation block	Duke University	Mariano Garcia-Blanco, M.D., Ph.D.	Medicine
Amy Estelle Pickar Construction and expression of anti-melanoma human monoclonal antibody fragments in phage Lambda	Duke University	Hilliard F. Seigler, M.D.	Microbiology and Immunology
Barbara Ann Pippin Cytokine gene transfection as immunotherapy of murine tumors	University of Pittsburgh	Michael T. Lotze, M.D.	Surgery/Molecular Genetics/ Biochemistry
Stacy Lynne Smith Mechanism of the switch to the angiogenic phenotype in rat chondrosarcoma	Harvard University	Judah Folkman, M.D.	Surgery
Kimberly Crapo Stone Quantitative investigation of axonal organelle constituents with transient blockage of fast axonal transport	Duke University	Michael P. Sheetz, Ph.D.	Cell Biology
Renee J. Strucke Diversity of the gamma delta T cell receptor in normal and diseased skin	Harvard University	Paul Bleicher, M.D., Ph.D.	Dermatology
William Hudson Sweatt Immunologic factors that limit maternal-fetal transmission of HIV	Johns Hopkins University,	James E. K. Hildreth, M.D., Ph.D.	Pharmacology
Alison Patricia Toth Modulation of proliferation and differentiation in human chondrosarcoma by peptide growth factors	Duke University	Sean P. Scully, M.D., Ph.D.	Orthopedic Surgery

Name	Fellowship Institution	Research Mentor	Department
Genetics and Molecular Biology			
Hugh B. Carey	Yale University (University of Connecticut)*	Michael Kashgarian, M.D.	Pathology
The role of Na+/K+-ATPase and the cytoskeleton in recovery of cell polarity following ischemic injury			
Rohan Hazra	Johns Hopkins University	Garry R. Cutting, M.D.	Pediatrics
Novel GABA receptor subunits: tissue expression and functional analysis			
Catherine Marshall Hurt	University of California–San Francisco	Mary L. Williams, M.D.	Dermatology/Pediatrics
Regulation of epidermal lipid synthesis during fetal rat development			
Jennifer Ellen Lawrence	Johns Hopkins University	Arthur Feldman, M.D., Ph.D.	Medicine
Characterization of a unique gene which is differentially regulated in a cardiomyopathic hamster			
Benhur Lee	Yale University	Joseph E. Craft, M.D.	Medicine/Rheumatology
Characterization of Th ribonucleoprotein particle (Th RNP)			
John Halvor Lee	University of Minnesota–Twin Cities	Richard W. Linck, Ph.D.	Cell Biology/Neuroanatomy
Molecular biology of tektins and microtubules			
Kristi Levine	Cornell University Medical Center	Wilson H. Miller, M.D., Ph.D.	Medicine
PCR study of the molecular rearrangement of acute promyelocytic leukemia (APL)			
Victoria Alexandra Mancuso	University of California–San Francisco	Tristram G. Parslow, M.D., Ph.D.	Pathology/Microbiology/ Immunology
Functional homologues of an effector domain from the HIV-1 rev transactivator			
William Hikaru Matsui	University of California–San Francisco	Keith R. Yamamoto, Ph.D.	Biochemistry and Biophysics
Transcription factor interactions at composite glucocorticoid response elements			
Mitra Maybodi	Duke University	Donald L. Granger, M.D.	Microbiology and Immunology
Role of macrophage-derived nitrogen oxides as antimicrobials during dormant intracellular infections			
Margaret Elise McLaughlin	Harvard University (University of Pennsylvania)*	Thaddeus Dryja, M.D.	Ophthamology
The role of the B subunit of rod cGMP-phosphodiesterase in retinitis pigmentosa			
Jennifer Lee Willert	University of California–San Francisco	Philip Cogen, M.D., Ph.D.	Neurosurgery and Pediatrics
Deletion mapping and characterization of distal chromosome 17p tumor suppressor gene in pediatric intracranial neoplasm			
Julie Anne Wissink	Stanford University	James I. Mullins, Ph.D.	Microbiology and Immunology
Expression and characterization of an envelope glycoprotein from an acutely pathogenic simian immunodeficiency virus			
Neuroscience and Physiology			
Nicholas M. Boulis	Harvard University	Larry Benowitz, Ph.D.	Neurosurgery
Expression of trophic factors supporting CNS regeneration *in vivo*			
Mark Anthony Hester	Duke University	George G. Somjen, M.D.	Cell Biology
In vitro investigation of ischemic brain damage			
John Victor Heymach	Stanford University	Eric M. Shooter, Ph.D.	Neurobiology
The role of the propeptide in the targeting and processing of neurotrophins			
Brian Frederick Hoeflinger	Medical College of Ohio	Robert W. Rhoades, Ph.D.	Anatomy
Patterned activity and neuronal death			
Sigmund Huang Hsu	Brown University	Edward Hawrot, Ph.D.	Molecular Pharmacology
Structure/function analysis of alpha-neurotoxin interactions with nicotinic acetylcholine receptor			
Delphine Hu	Harvard University (Yale University)*	Charles B. Berde, M.D., Ph.D.	Anesthesia
Sustained release of local anesthetics: potential method for prolonged regional anesthesia			
Patti Chia-Sue Huang	Duke University	Fulton Wong, Ph.D.	Ophthalmology
Pathophysiology of rhodopsin mutations in retinal degeneration			
Kimberly Susan Kauffman	Duke University	Theodore A. Slotkin, Ph.D.	Pharmacology
The effect of maternal glucocorticoid use on fetal cardiovascular adaptations			
Lori Jean Kutka	Washington University	William D. Snider, M.D.	Neurology
Regulation of corticospinal axon branching in mammalian spinal cord			
Christine G. Lydon	Yale University	Manohar M. Panhabi, Ph.D.	Orthopedics
Biomechanics of cervical spine whiplash injuries			
Elizabeth Mwikali Mutisya	Harvard University	M. Flint Beal, M.D.	Neurology
Correlation of β-amyloid toxicity with declining energy metabolism			

* A medical school affiliation other than the fellowship institution is indicated in parentheses.

Continued Awards—Second Year of Research

Anne-Marie Brillantes	Mount Sinai School of Medicine	Andrew R. Marks	Molecular Medicine
Functional characterization and regulation of the Ryanodine Receptor (Calcium Release Channel)			
Agnes Marks Cartner	University of Alabama at Birmingham	Albert F. LoBuglio	Medicine
Establishment of an animal model to study the immunogenicity of monoclonal antibodies			
Jeffrey A. Guy	Harvard University	Wilson C. Hayes	Orthopedic Surgery
Long term effects of alendronate in ovariectomized rats			
Barbara Ann Zylbert	Stanford University	Alan Krensky	Pediatrics
Biochemical analysis of human-murine chimeric T-cell antigen receptor heterodimers in lipid-linked form			

Continued Awards—Return to Medical Studies

Ravi Allada	University of Michigan–Ann Arbor
Sharon Ann Bloom	Stanford University
Marc Carruth	Duke University
Evelyn Mary Gonzalez	Harvard University
Ronell Allen Hansen	University of Minnesota–Twin Cities
Raymond Issac Haroun	Columbia University
Donald Vincent Heck	Duke University
Erica W. Hwang	University of Michigan–Ann Arbor
Hanlee P. Ji	Johns Hopkins University
Bamidele Omowunmi Kammen	Harvard University
Sandeep Kunwar	University of California–San Francisco
Edward Earl Leonard II	University of Pittsburgh
Matthew Lonergan	Harvard University
Marga Faith Massey	Duke University
Samuel Mark Moskowitz	Harvard University
Lisa Michelle Owens	University of North Carolina at Chapel Hill
Christian Paul Pavlovich	University of California–San Francisco
Daniel A. Peterson	Rush University
Vivek Yerrapu Reddy	University of Michigan–Ann Arbor
Mark Andrew Robien	Tufts University School of Medicine
Christine Marie Seroogy	University of Minnesota—Twin Cities

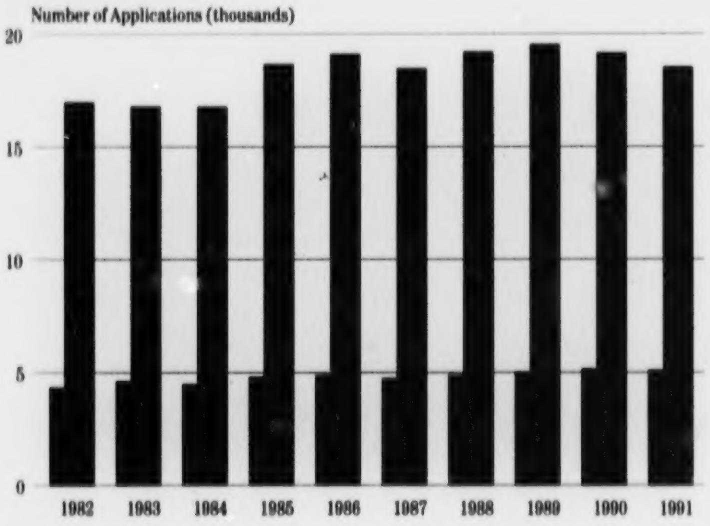
gram as a result of the fellowship experience. Others intend to pursue postdoctoral research training after completing medical school and postgraduate clinical training.

The Institute is interested not only in the career paths of its fellows but also in the size, composition, and activities of the national pool of physician-scientists. Pursuit of both these interests is described in the Program Assessment section of this report.

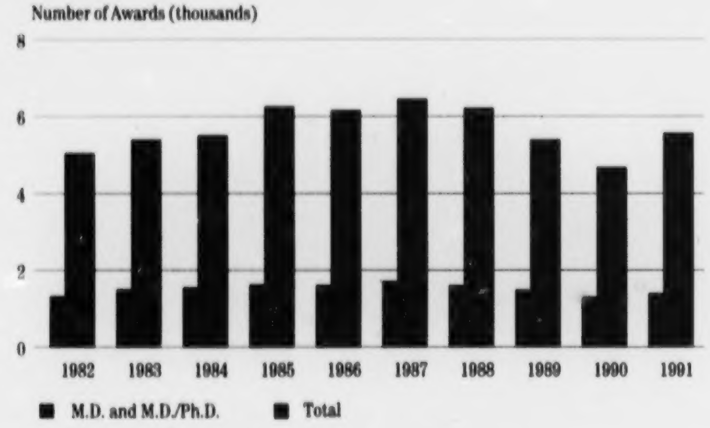
Figure 13

NIH Research Projects, 1982-1991

Competing Applications



Competing Awards



SOURCE: National Institutes of Health, Division of Research Grants. Analysis by Carol Bleakley, 1992.

NOTE: Research Projects include Research Project Award (RO1), New Investigator Research Awards, FIRST Awards, Outstanding Investigator Grants, MERIT Awards, Small Business Innovation Research Grants, Research Program Project Awards (PO1), Hazardous Substance Basic Research Grants, U.S.-Japan Cooperative Medical Science Program Awards, and Research Projects Cooperation Agreements.

Postdoctoral Research Fellowships for Physicians

The pace of fundamental discoveries emerging from biomedical research has been remarkable in recent years, yielding significant new understanding. To reap the benefits of this knowledge, now and in the future, it is vital that physicians remain involved in fundamental research (Figures 13 and 14).

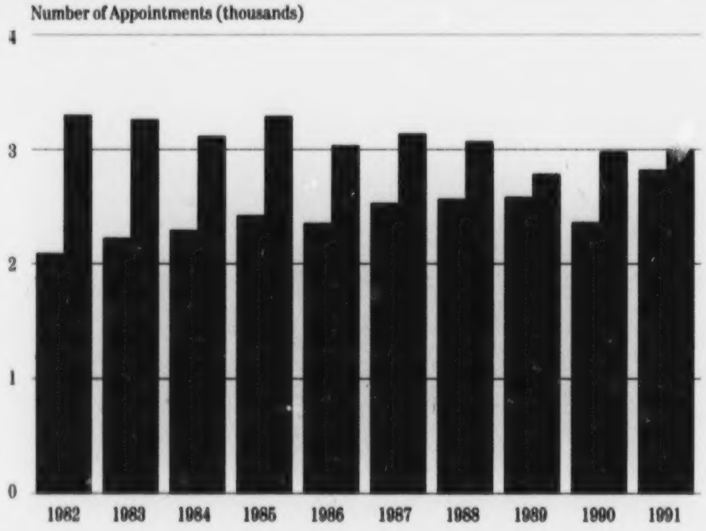
The goal of the Institute's Postdoctoral Research Fellowships for Physicians is to help increase the number of well-trained physician-scientists. The awards are intended for physicians who are seeking additional training with a view to becoming independent investigators when they assume faculty or other research positions.

A physician who has completed at least two years of postgraduate clinical training and less than two years of postdoctoral training in fundamental research is eligible to apply for the fellowship, which provides support for three years of full-time research training in the laboratory of the applicant's choice. Support is provided for fundamental research directed toward an understanding of basic biological processes and disease mechanisms, especially in the areas of the Institute's research program. Awards are made to those applicants who demonstrate superior scholarship and show greatest promise for future achievement in biomedical research (Figure 15).

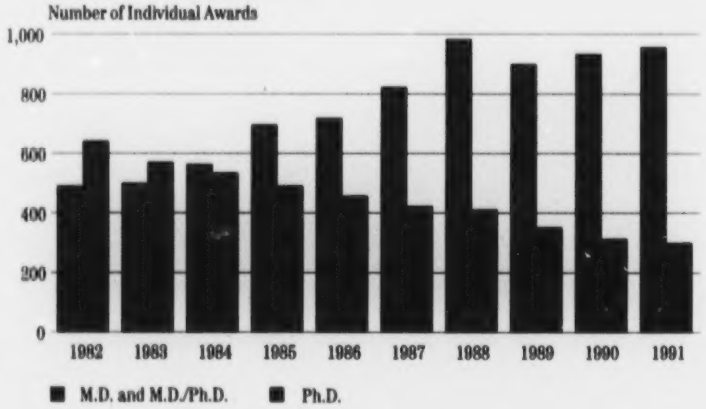
Figure 14

NIH-Supported Advanced Research Training Awards, 1982–1991

Postdoctoral Appointments



Career Development Awards



SOURCE: National Institutes of Health, NIH Data Book 1992, Bethesda, Maryland: National Institutes of Health.

NOTE: About 15% of the postdoctoral appointments for M.D.'s and 40% of those for Ph.D.'s are through individual awards. The remaining appointments are made through institutional awards.

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Figure 15

Postdoctoral Research Fellowships for Physicians Program and Award Highlights

Fellowship Terms

- 25 awards annually
- 3 years of support
- $62,000—$77,000 annually
  - $35,000—$50,000 stipend*
  - $15,000 research allowance
  - $12,000 institutional allowance

Eligibility

- M.D., M.D./Ph.D., D.O., or M.B.B.S. degree
- Full-time fundamental research (basic biological processes and disease mechanisms)
- Any academic or not-for-profit research institution
- No enrollment in a graduate degree program
- No faculty appointment
- At the start of the fellowship
  - first medical degree no more than 10 years earlier
  - at least two years of postgraduate clinical training
  - no more than two years of postdoctoral research training

1992 Awards

- Total number: 34
  - 9 women and 25 men
  - 27 U.S. citizens and 7 foreign citizens
  - 13 M.D.'s and 21 M.D./Ph.D.'s
  - 3 minorities underrepresented in the sciences
- Fellowship institutions: 22

All Current Physician Research Fellows

- Total number: 69 fellows
  - 17 women and 52 men
  - 61 U.S. citizens and 8 foreign citizens
  - 31 M.D.'s and 38 M.D./Ph.D.'s
  - 3 minorities underrepresented in the sciences
- Fellowship institutions: 40

* *Effective September 1993 the stipend range will change to $35,000—$55,000.*

Note: Awardees who selected mentors at HHMI laboratories are appointed as associates of the Institute. Of the 34 new awardees, 4 have been appointed as associates of the Institute and 30 are fellows. No awardees appointed as associates are included in the data under all current physician research fellows.

The Institute's Postdoctoral Research Fellowships for Physicians will complement the approximately 2,700 postdoctoral appointments for M.D.'s made possible through NIH programs. The Institute's fellowship program should help increase the number of well-trained physician-scientists highly competitive for NIH career development awards, research project grants, and similar private and public sector support.

The first awards in the Institute's program were made in the fall of 1990. In 1992 a panel of eminent biomedical scientists from universities and medical centers across the United States evaluated more than 150 applications. On the basis of the panel's review, the Institute named 30 physician research fellows and 4 HHMI associates, who will receive their research training in the laboratories of highly distinguished mentors at 22 universities, research institutes, and hospitals. The HHMI associates will work in the laboratories of Institute investigators (Figure 16).

The Institute plans to award about 25 three-year fellowships annually, based on an international competition. Awards will be made on the basis of the applicants' ability and promise and the quality of the research training to be provided through this program. At present 69 physician research fellows are being supported annually through the grants program, at an annual cost of nearly $5 million (Figure 17).

Among its ongoing program assessment activities, the Institute

Figure 16

Postdoctoral Research Fellowships for Physicians—1992 Awardees Educational Origins

Medical Schools

Albert Einstein
Baroda Medical College, India
Baylor College of Medicine
Case Western Reserve University
Catholic University, Italy
Duke University
Emory University
Harvard University, 3
Johns Hopkins University, 3
Kansas University
Keio University, Japan
Meharry Medical College
Nanjing Medical College, China
Northwestern University
Shanghai Medical University, China
State University of New York Syracuse Health Sciences Center
University of Arizona
University of California– San Diego
University of Chicago, 2
University of Iowa
University of Melbourne
University of Michigan– Ann Arbor
University of North Carolina at Chapel Hill
University of Pennsylvania, 2
Washington University
Yale University, 3

Graduate Schools (for M.D./Ph.D.'s)

Albert Einstein College of Medicine
Baylor University
Case Western Reserve University
Duke University
Emory University
Harvard University
Johns Hopkins University, 2
Meharry Medical College
Tufts University
University of California– San Diego
University of Chicago, 2
University of Miami
University of Massachusetts
University of Michigan– Ann Arbor
University of Pennsylvania
Walter and Eliza Hall Institute, Australia
Washington University
Yale University, 2

Undergraduate Institutions

Brown University, 3
Catholic University, Italy
Clemson University
College of William and Mary
John Carroll University
Johns Hopkins University
Fairfield University
Harvard University, 3
Keio University, Japan
Massachusetts Institute of Technology
Miami University
Morehouse College
M.S. University, India
Nanjing Medical College, China
Shanghai Medical University, China
Siena College
St. John's College
Stanford University, 2
University of Arizona
University of Illinois at Urbana/Champaign, 3
University of Iowa
University of Melbourne, Australia
University of Michigan– Ann Arbor
University of North Carolina at Chapel Hill
University of Notre Dame
University of Pennsylvania
Yale University

High Schools

Arizona
Central, Phoenix
California
Henry M. Gunn, Palo Alto
C. K. McClatchy, Sacramento
District of Columbia
St. Albans
Illinois
Forrest View, Arlington Heights
Joliet Catholic, Joliet
Rolling Meadows, Rolling Meadows
York Community, Elmhurst
Indiana
Lafayette Central Catholic, Lafayette
Kansas
Blue Valley, Stanley
Maryland
Pikesville, Baltimore
Walt Whitman, Bethesda
Charles W. Woodward, Rockville
Massachusetts
Greater Boston Academy, Stoneham
Malden, Malden
Michigan
Dearborn, Dearborn
New Jersey
Montclair Kimberley Academy, Montclair
New York
Carle Place, Carle Place
Stuyvesant, New York City
North Carolina
Grimsley, Greensboro
Ohio
Beavercreek, Beavercreek
St. Ignatius, Cleveland
Pennsylvania
Cheltenham, Wyncote
Cumberland Valley, Mechanicsburg
Hempfield, Lancaster
South Carolina
Chester, Chester
Outside the United States
Carey Baptist, Melbourne, Australia
Convent of Jesus and Mary, Baroda, India
Dan-Yang, Dan-Yang, China
Federal School of Science, Lagos, Nigeria
Keio Gijuku, Yokohama, Japan
Liceo Classico P. Giannone, Benavento, Italy
Mount Alvernia, Montego Bay, Jamaica
Nanjing, Nanjing, China

will continue to monitor the national participation of M.D.'s and M.D./Ph.D.'s in research, and will track the careers of its physician-scientist fellows, including faculty appointments and receipt of research grants (see Program Assessment, page 89).

Figure 17

Postdoctoral Research Fellowships for Physicians Fellowship Institutions, 1990–1992

Albert Einstein College of Medicine
Baylor College of Medicine
Brigham and Women's Hospital
Case Western Reserve University
Children's Hospital, Boston
Childrens Hospital of Los Angeles
Children's Hospital of Philadelphia
Columbia University
Dana-Farber Cancer Institute
Dartmouth College
Duke University Medical Center
Fred Hutchinson Cancer Research Center
Harvard Medical School
Harvard School of Public Health
Harvard University
J. David Gladstone Institutes
Johns Hopkins University School of Medicine
Julius Maximilians University, Germany
Massachusetts General Hospital
Massachusetts Institute of Technology
Max Planck Institute for Experimental Medicine, Germany
National Institutes of Health
National Jewish Center for Immunology and Respiratory Medicine
Northern California Institute for Research and Education
Northwestern University
Oregon Health Sciences University
Rockefeller University
Salk Institute for Biological Studies
Stanford University School of Medicine
State University of New York College at Buffalo
State University of New York at Stony Brook
University of California–San Diego
University of California–San Francisco
University of Chicago
University of Colorado Health Sciences Center
University of Houston
University of Massachusetts Medical Center
University of Michigan–Ann Arbor
University of North Carolina at Chapel Hill
University of Pennsylvania
University of Washington
Vanderbilt University School of Medicine
Washington University
Whitehead Institute for Biomedical Research
Yale University School of Medicine

Research Resources

The Research Resources Program provides support to research and educational organizations that serve as unique national resource laboratories and teaching facilities, including those that provide biological stocks and materials for the biomedical research community.

Four grants awarded in earlier years continued to support research resource activities in 1992–1993. These awards were made to the following institutions:

- Cold Spring Harbor Laboratory
  Cold Spring Harbor, New York
- Marine Biological Laboratory
  Woods Hole, Massachusetts
- Institute of Laboratory Animal Resources
  National Research Council/
  National Academy of Sciences
  Washington, D.C.
- Human Genome Organisation
  Bethesda, Maryland

Cold Spring Harbor Laboratory

A four-year grant in the amount of $1 million was awarded to the Cold Spring Harbor Laboratory in 1991

Postdoctoral Research Fellowships for Physicians—1992 Awardees

Name	Research Mentor	Fellowship Institution	Department
Cell Biology and Regulation			
William Bishai, M.D., Ph.D. Searching for the USSR: efforts to identify a *Haemophilus influenzae* transformation protein involved in self-DNA replication	Hamilton O. Smith, M.D.	Johns Hopkins University School of Medicine	Molecular Biology and Genetics
Joseph Bokar, M.D., Ph.D. Purification and characterization of N-6-methyladenosine methyltransferase	Fritz M. Rottman, Ph.D.	Case Western Reserve University	Molecular Biology and Microbiology
George Cotsarelis, M.D. Characterization of hair follicle stem cells	Mark I. Greene, M.D., Ph.D.	University of Pennsylvania	Pathology and Laboratory Medicine
Robert D'Amato, M.D., Ph.D. Analysis of the factors which influence retinal angiogenesis	Judah Folkman, M.D.	Children's Hospital, Boston	Surgery
David Frank, M.D., Ph.D. The role of the retinoblastoma gene product in PC12 cell neuronal differentiation	Michael E. Greenberg, Ph.D.	Harvard Medical School	Microbiology and Molecular Genetics
Mary Gray, M.D. Regulation of angiotensin II signaling in myocardial hypertrophy	Joel S. Karliner, M.D.	Northern California Institute for Research and Education	Medicine
Antonio Iavarone, M.D. The function of p53 in tumor suppression	Mark A. Israel, M.D.	University of California–San Francisco	Neurological Surgery
Dean Kedes, M.D., Ph.D. Dissecting microtubule-based cytoplasmic motility using animal viruses	Don Ganem, M.D.	University of California–San Francisco*	Microbiology
John Krege, M.D. An animal model for studying the role of angiotensin-converting enzyme (ACE) in hypertension	Oliver Smithies, D. Phil.	University of North Carolina at Chapel Hill	Pathology
Jose Leis, M.D., Ph.D. Studies of the retinoblastoma gene product pRB expressed in fission yeast	David M. Livingston, M.D.	Dana-Farber Cancer Institute	Neoplastic Disease Mechanisms
Thomas McGarry, M.D., Ph.D. Control of mesoderm differentiation by fibroblast growth factor	Marc W. Kirschner, Ph.D.	University of California–San Francisco	Biochemistry and Biophysics
Genetics			
Johanna Daily, M.D. Molecular basis of drug resistance in malaria	Dyann F. Wirth, Ph.D.	Harvard School of Public Health	Tropical Health
Douglas Feltner, M.D. Analysis of the developmental function of the mouse *Dlx-2* gene	Kathleen A. Mahon, Ph.D.	NICHD–National Institutes of Health	Mammalian Genes and Development
Jonathan Graff, M.D., Ph.D. Biochemical and molecular characterization of the *Wnt* gene family	Douglas A. Melton, Ph.D.	Harvard University	Biochemistry and Molecular Biology
Kazuto Kajiwara, M.D. The study of the human retinal degeneration slow *(RDS)* gene and its role in retinal degeneration	Thaddeus P. Dryja, M.D.	Harvard Medical School	Ophthalmology
Gail Pairitz-Jarvik, M.D., Ph.D. Genetic heterogeneity of hyperlipidemia: the genetic architecture of apolipoprotein B levels	Arno G. Motulsky, M.D., Sc.D.	University of Washington	Medical Genetics
Immunology			
Joan Butterton, M.D. Genetically-engineered live oral vaccines for *Vibrio cholerae*	Stephen B. Calderwood, M.D.	Massachusetts General Hospital	Infectious Disease
Suzanne Conzen, M.D. Analysis of the cellular gene response to SV40 T antigen	Charles N. Cole, Ph.D.	Dartmouth Medical School	Biochemistry
Michael Hagensee, M.D., Ph.D. Human papillomavirus capsid structure, receptor, and immune response	Denise A. Galloway, Ph.D.	Fred Hutchinson Cancer Research Center	Cancer Biology
Shan Lu, M.D., Ph.D. Structures of HIV-1 envelope glycoprotein in determining the *in vitro* growth potential and sensitivity to neutralizing antibody responses	Harriet L. Robinson, Ph.D.	University of Massachusetts Medical Center	Pathology
John Ogundipe, M.D., Ph.D. The role of a *Schistosoma mansoni* serpin in host-parasite interaction	Ronald Blanton, M.D.	Case Western Reserve University	Medicine
Peter Pertel, M.D. Glycoprotein B heparin-binding activity in herpes virus infectivity	Patricia G. Spear, Ph.D.	Northwestern University	Microbiology and Immunology
Lalita Ramakrishnan, M.D., Ph.D. Mechanism of mycobacterial entry into host cells	Stanley Falkow, Ph.D.	Stanford University School of Medicine	Microbiology and Immunology
Dennis Walling, M.D. EBV pathogenesis in HIV patients with hairy leukoplakia	Nancy Raab-Traub, Ph.D.	University of North Carolina at Chapel Hill	Microbiology and Immunology
Wendy Ward, M.D. The cysteine protease of *Giardia lamblia* is a promising target for structure-based design of new antiparasitic drugs	James H. McKerrow, Ph.D., M.D.	University of California–San Francisco	Pathology
Neuroscience and Physiology			
Robert Chow, M.D., Ph.D. Function of synaptic vesicle proteins	Walter Stühmer, Ph.D.	Max Planck Institute for Experimental Medicine, Germany	Membrane Biophysics
Timothy Kamp, M.D., Ph.D. Molecular characterization of ion permeation through Ca^{++} channels	Eduardo Marban, M.D., Ph.D.	Johns Hopkins University School of Medicine	Medicine
Trevor Kilpatrick, M.D., Ph.D. The role of novel protein-tyrosine kinases in the epigenetic regulation of glial development	Greg Lemke, Ph.D.	Salk Institute for Biological Studies	Molecular Neurobiology
Maxine Lee-Mengel, M.D. Effects of anesthetic drugs on cardiac performance and metabolism	Georg Ertl, M.D.	Julius Maximilians University, Germany	Medicine
Barry London, M.D., Ph.D. Structural determinants of voltage gating in cloned potassium channels	Bernardo Nadal-Ginard, M.D., Ph.D.	Children's Hospital, Boston*	Cellular and Molecular Physiology
Pamela Sklar, M.D., Ph.D. Glutamate-gated ion channels: RNA editing in the brain	Richard Axel, M.D.	Columbia University College of Physicians and Surgeons*	Biochemistry and Pathology
David Standaert, M.D., Ph.D. Excitatory amino acid receptor genes in the striatum	Anne B. Young, M.D., Ph.D.	Massachusetts General Hospital	Neurology
Scott Turner, M.D., Ph.D. Amyloid precursor protein processing in human CNS neuronal cells (NT2-N)	Virginia M.Y. Lee, Ph.D.	University of Pennsylvania	Pathology and Laboratory Medicine
Zi-Jian Xu, M.D., Ph.D. Investigation of the molecular mechanisms of the voltage-dependent ion channels	Richard W. Aldrich, Ph.D.	Stanford University School of Medicine*	Molecular and Cellular Physiology

*Howard Hughes Medical Institute

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Figure 18

Cold Spring Harbor Laboratory Courses Supported by the Howard Hughes Medical Institute

Summer 1991

- Molecular Approaches to Ion Channel Function and Expression
- Imaging Structure and Function in the Nervous System

Fall 1991

- Macromolecular Crystallography
- Molecular Genetics of Fission Yeast

for support of its expanded program of postgraduate courses during the period 1992–1995. The postgraduate education program of the Laboratory has been one of enduring quality and scope known worldwide. This award continues support provided in an earlier grant to enable the Laboratory to add courses in the areas of molecular genetics, neurobiology, and structural biology. The new grant provides funds for equipment and supplies, instructors and guest lecturers, scholarships for students, and support personnel.

The laboratory is a world center for biological research and training, especially in the genetics of humans, plants, and bacteria. It serves as an international schoolhouse for modern biology, annually hosting major conferences, seminars, teaching workshops, and courses for participants across a range of educational levels, including precollege students and teachers, undergraduates, graduate students, postdoctoral fellows, and established scientists at major universities and research centers. The new Hughes Teaching Laboratories, an integral part of the neuroscience teaching and research facility, was constructed with Institute support. In the summer of 1991, for the first time, it was home to three courses: Molecular Embryology of the Mouse, Advanced Molecular Cloning, and Molecular Cloning of Neural Genes. In 1992 these teaching laboratories also will house Molecular Approaches to Ion Channel Expression and Function and Imaging Structure and Function in the Nervous System.

A $7 million, three-year grant awarded to the Cold Spring Harbor Laboratory in 1987 has continued to support the postgraduate training program in neuroscience and structural biology during 1992. Institute funds have enabled the Laboratory to expand its postgraduate courses to include a series of intensive two-week courses (in the spring and fall) to complement its usual summer program, which also is partially supported by the grant. The four Institute-supported courses were attended by 49 students. Participants came from the United States and abroad (Argentina, Australia, Canada, Denmark, Germany, Hungary, Israel, Sweden, Switzerland, and the United Kingdom) (Figure 18).

Marine Biological Laboratory

A grant of $4 million awarded to the Marine Biological Laboratory in 1988 is supporting training and education programs for a period of seven years. The Laboratory has served as a center for research and teaching in basic biology since 1888. Each summer, investigators and advanced students come to the Laboratory to study basic life sciences, using marine organisms from the surrounding waters. Educational and research programs are closely intertwined. The Marine Biological Laboratory/Woods Hole Oceanographic Institute (MBL/WHOI) Library, which supports the education and research programs with 24-hour access, ranks as one of the world's most comprehensive repositories of biomedical and marine biological information.

The grant provides $3 million directed to courses in embryology, microbiology, neuroscience, and physiology. In the summer of 1991, the grant helped support eight courses. The 213 participants were selected from almost 500 applicants, including graduate students, postdoctoral fellows, and faculty at universities and research institutions in the United States and abroad (Australia, Austria, Canada, France, Germany, India, Israel, Italy, Sweden, Switzerland, United Kingdom, the former USSR, and Yugoslavia) (Figure 19).

The grant also provides $1 million to support program development at the MBL/WHOI Library. Emphasis has been on electronic information storage, retrieval, and management to support scientific research and education. Grant-supported activities include establishing a linked network among the research facilities of the Marine Biological Laboratory and Woods Hole Oceanographic Institute and their classroom and laboratory teaching facilities; purchasing computer hardware and software applications, including those needed for nucleic acid and protein sequence analyses; and establishing a formal consulting, problem solving, and education program.

Institute of Laboratory Animal Resources

A $500,000, three-year grant was awarded to the Institute of Laboratory Animal Resources (ILAR), National Research Council/National Academy of Sciences, in 1988. ILAR publishes standard reference documents on the care and use of laboratory animals, maintains a directory of sources, and convenes expert groups to consider scientific and public policy issues relevant to the use of animals in research. These activities continue under an extended grant period.

With Institute grant funds, the Committee on Transgenic Nomenclature developed, field tested, and promulgated rules for standardized nomenclature of transgenic mice and other animals. The ILAR Council plans to continue to pursue development of guidelines for colony management of transgenic organisms, suggest methods of preserving these unique resources, and recommend policies and procedures for their development, use, and disposition.

The grant continues to support the Animal Models and Genetic Stocks Information Programs and the workshops for teachers and science coordinators to discuss published ILAR guidelines for use of animals in precollege education. Publications released in the past year include *Important Laboratory Animal Resources: Selection Criteria and Funding Mechanisms for Their Preservation* and *Recognition*

Figure 19

Marine Biological Laboratory Courses Supported by the Howard Hughes Medical Institute

- Cellular Neurobiology and Development of the Leech
- Embryology: Cell Differentiation and Gene Expression in Early Development
- Methods in Computational Neuroscience
- Microbial Diversity
- Molecular Evolution
- Neural Systems and Behavior
- Neurobiology
- Physiology: Cell and Molecular Biology

and Alleviation of Pain and Distress in Laboratory Animals.

Human Genome Organisation

In 1990, the Human Genome Organisation (HUGO) received a four-year award of $1 million for the program and operations of its Americas Office and related international activities, including meetings of the HUGO Council, committee workshops, and a scientist exchange program. HUGO serves as a coordinating body for the international human genome project.

This organization is an international clearinghouse for information on the DNA base sequences and the genetic and physical mapping of human chromosomes. It fosters collaboration among scientists in the exchange of data, samples, and technology relevant to the genome research and fosters studies of model organisms (such as the mouse) to parallel the effort on the human genome. HUGO also plans to establish international training programs on methodology and to encourage public debate on the ethical, legal, and other societal impacts of the human genome project.

In the past year HUGO Americas, HUGO Europe, and HUGO Pacific, together issued *Guidelines for the Organisation of Single Chromosome Workshops.* HUGO Americas participated in workshops on 17 chromosomes, as well as meetings on genetic diversity.

Undergraduate Science Education

Since 1988 the Institute's Undergraduate Biological Sciences Education Program has supported colleges and universities in strengthening undergraduate education in biology and in chemistry, physics, and mathematics as they relate to biology. A major objective is to provide undergraduates with laboratory research opportunities, thereby encouraging students to prepare for graduate studies in research or medicine and for careers in biomedical research and education. By supporting such research experiences, the Institute hopes to increase the numbers of women and minorities, including blacks, Hispanics, Native Americans, and other groups underrepresented in the sciences, who pursue careers in biology and related scientific disciplines.

Another objective is to enhance undergraduate science education by helping institutions bring fresh perspectives to teaching established fields and by developing new programs in emerging areas. The Institute also seeks to broaden the academic base of biology by promoting closer integration of biology teaching with other scientific fields and by providing biology students with a firm grounding in these disciplines. An additional objective is to help strengthen linkages between institutions of higher learning and elementary and secondary schools, two-year and junior colleges, and other four-year institutions in order to attract and retain students in the sciences and to enhance science teaching programs at these institutions.

Undergraduate Program Directors Meetings

As part of its ongoing assessment endeavor, the Institute brings together the directors of undergraduate programs it supports. These meetings provide a forum for the participating institutions to exchange information and experiences. They also provide the Institute with the opportunity to learn more about the activities it has funded and to gain important background on the priorities and needs of undergraduate science education for future program development. To inform the scientific and educational communities of these activities, the Institute publishes proceedings and other reports, which are distributed nationally.

The 1991 and 1992 meetings focused on programs supported in the initial two rounds of undergraduate competition (1988 and 1989). Subsequent meetings will be held for program directors at institutions funded in later years of the undergraduate program.

1991 Meeting

The initial meeting of the program directors focused on undergraduate research and precollege and outreach activities funded by the Institute at the grantee institutions. The proceedings of this meeting and individual program descriptions are included in the Institute publication ***Attracting Students to Science: Undergraduate and Precollege Programs, 1992.***

Throughout the presentations and discussions, program directors from a wide range of public and private institutions, including major research universities, comprehensive institutions, and four-year liberal arts colleges, emphasized the importance of direct, hands-on laboratory research experiences for undergraduates and precollege students. They described the numerous benefits of these experiences, such as opportunities for students to learn at first hand the concepts, techniques, and terminology of science, the close working relationships established with science faculty, and the application of classroom learning to research problems. Laboratory research at an early level has the added advantage of tapping students' natural curiosity and attracting them to scientific careers.

At Xavier University of Louisiana, the Institute grant is supporting major expansion of a program to interest underrepresented minority students in the sciences and to retain their interest through activities that, for most participants, provide their first exposure to the laboratory. Deidre Labat, Professor of Biology and program director at Xavier, described the University's activities, which include ongoing laboratory and classroom training in biology, chemistry, and mathematics for students from junior high through college. The program at Xavier, which has served as a model for other institutions throughout the United States, has seen a sharp increase in student participation since the Institute award. Approximately 550 students participated in Xavier's outreach programs in 1992. (Dr. Labat was appointed Associate Dean of Xavier University in 1992.)

Samuel Ward, Professor and Head of the Department of Molecular and Cellular Biology and program director at the University of Arizona, presented the Institute-supported undergraduate research program at his institution. In 1991–1992 the Institute award enabled 83 students, of whom 15 percent are from minority groups underrepresented in the sciences and 50 percent are women, to work in faculty research laboratories. The program involved 165 faculty members from 26 science departments or schools throughout the institution. Dr. Ward described the early impact of the program, including increased student interest in pursuing Ph.D. and M.D./Ph.D. programs and research careers.

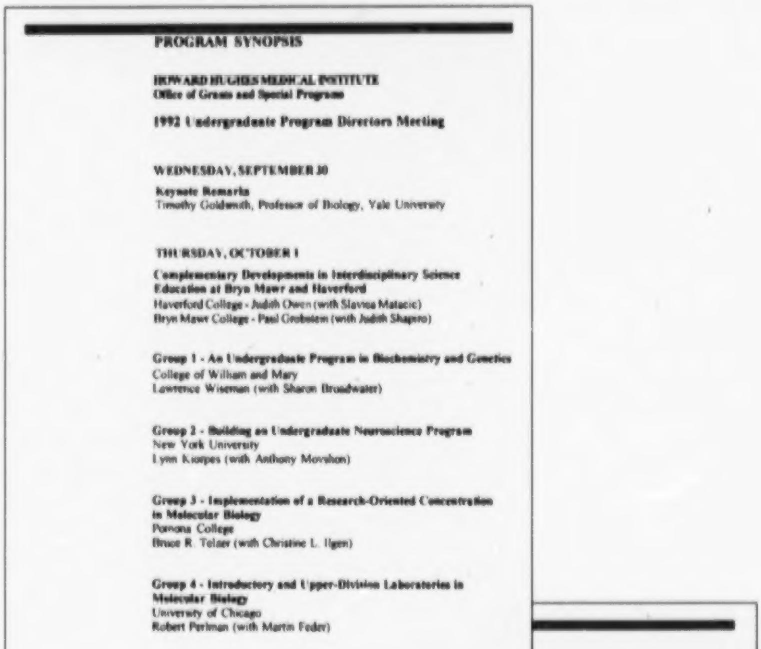
In another presentation, Dale Rogers Marshall, Dean of Wellesley College and program director, led a discussion on the importance of providing students, particularly women, with practicing scientists as role models. During 1991–1992 the Institute award at Wellesley supported 52 students, all of whom are women, in faculty research programs in such disciplines as cell biology, developmental biology, and neuroscience. The grant also provided support for laboratory equipment for undergraduate research. Dr. Marshall noted that a number of students have taken advantage of the opportunity afforded by the grant to supplement their laboratory experiences by traveling to scientific meetings to present their research and coauthoring papers in scientific journals with faculty mentors. (Dr. Marshall was appointed President of Wheaton College in Massachusetts in 1992.)

1992 Meeting

The theme of the 1992 undergraduate program directors meeting was curriculum and laboratory development and undergraduate research. Presentations focused on undergraduate programs at the introductory, intermediate, and upper-division levels in such fields as biochemistry, cell and molecular biology, genetics, and neuroscience. Program directors also explored approaches to integrating biology teaching with other scientific fields, developing interdisciplinary laboratory courses, and emphasizing hands-on research in the undergraduate curriculum. Reports from the meeting, including *Enriching the Undergraduate Laboratory Experience* and the *1993 Undergraduate Program Directory*, will be published early in 1993 (Figure 20).

Figure 20

1992 Undergraduate Program Directors Meeting Enriching the Undergraduate Laboratory Experience, September 30-October 2, 1992



PROGRAM SYNOPSIS

HOWARD HUGHES MEDICAL INSTITUTE
Office of Grants and Special Programs

1992 Undergraduate Program Directors Meeting

WEDNESDAY, SEPTEMBER 30

Keynote Remarks
Timothy Goldsmith, Professor of Biology, Yale University

THURSDAY, OCTOBER 1

Complementary Developments in Interdisciplinary Science Education at Bryn Mawr and Haverford
Haverford College - Judith Owen (with Slavica Matacic)
Bryn Mawr College - Paul Grobstein (with Judith Shapiro)

Group 1 - An Undergraduate Program in Biochemistry and Genetics
College of William and Mary
Lawrence Wiseman (with Sharon Broadwater)

Group 2 - Building an Undergraduate Neuroscience Program
New York University
Lynn Kiorpes (with Anthony Movshon)

Group 3 - Implementation of a Research-Oriented Concentration in Molecular Biology
Pomona College
Bruce R. Telzer (with Christine L. Ilgen)

Group 4 - Introductory and Upper-Division Laboratories in Molecular Biology
University of Chicago
Robert Perlman (with Martin Feder)

Interdisciplinary Educational Programs for Undergraduates
Case Western Reserve University
Norman Rushforth (with Hillel Chiel)

FRIDAY, OCTOBER 2, 1992

Research Training in the Undergraduate Curriculum
University of California, Santa Cruz
Clifton Poodry (with Jerry Feldman)

Group 1 - An Undergraduate Program in Computational Biology and Chemistry
Carnegie Mellon University
Susan Henry (with Robert Murphy)

Group 2 - Development of Biochemistry and Molecular Genetics Laboratory Courses and an Office of Research Careers
Morehouse College
J.K. Haynes

Group 3 - The Biology Core Curriculum
Oberlin College
David Benzing (with Janice Thornton)

Group 4 - A Model System for a Biochemistry/Molecular Biology Laboratory
Whitman College
Paul Yancey (with Ruth Norine Russo)

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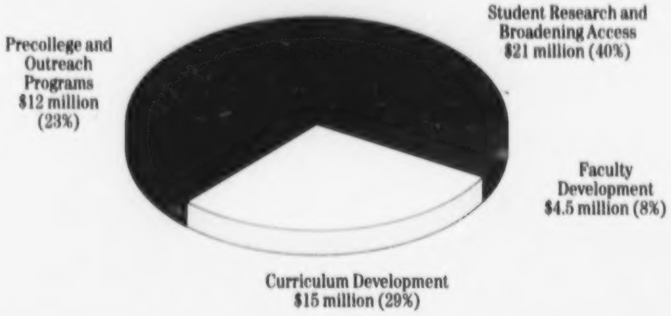
Figure 21

Undergraduate Biological Sciences Education Program Awards to 42 Universities ($52.5 million) by Program Component, 1992



New Awards, 1992

The Institute completed a fourth round of the competition for undergraduate grants in May 1992 and made awards totaling $52.5 million to 42 institutions. As in the previous three rounds, the Institute referred to classifications developed by the Carnegie Foundation for the Advancement of Teaching in identifying institutions for invitation to the graduate program. The Carnegie Foundation categorizes higher education institutions on the basis of factors such as enrollment, educational mission, and research and development funding by the federal government.

These 42 grantees competed within a pool of 98 institutions classified by the Carnegie Foundation as public and private Research Universities I and II and Doctorate-Granting Universities I and II. The Institute's five-year grants range from $1 million to $2 million each, and respond to the universities' proposals for support of a variety of activities in undergraduate science education (Figure 21). (See pages 43-50 for a list of the grantee institutions and descriptions of their awards.)

Undergraduate Research, Including Opportunities for Women and Minority Students Underrepresented in the Sciences

Of the $52.5 million, a total of $21 million will provide laboratory research experiences for undergraduates from the freshman through the senior years. At a number of institutions, grants provide students with close faculty collaboration in campus laboratories, and other grants will enable students to work off campus in laboratories of research universities and private industry. These laboratory experiences will be offered during the summer or academic year and, in some cases, during both periods. In addition, Institute funds will support activities to prepare students for laboratory research and to enable them to present their research at regional and national scientific meetings (Figure 22).

Each of the 42 grantee institutions will develop programs to attract and retain students in scientific fields by providing them with stipends to participate in laboratory research at their own institutions or at off-campus sites. A major emphasis of many of these programs will be to broaden access to the sciences for women and students from minority groups underrepresented in these areas.

Figure 22

Student Research and Broadening Access Programs, 1992

North Carolina State University

Opportunities for undergraduates, including women and students from minority groups underrepresented in the sciences, to prepare for careers in research, science education, and medical practice through research in laboratories off campus and in government and industrial laboratories in nearby Research Triangle Park.

University of California, Berkeley

A program for introductory-level students, particularly those from underrepresented minority groups, to relate concepts and techniques learned in science courses to research problems in faculty laboratories, to include summer and academic-year laboratory experiences, symposia, tutorials, and faculty mentoring.

University of New Mexico

Year-long laboratory research experiences for students, particularly black, Hispanic, and Native American undergraduates; opportunities to present research nationally and locally; and programs on careers in biology and related disciplines offered by science departments.

University of Pittsburgh

Undergraduate research training and laboratory experiences, supplemented by workshops on research concepts and techniques in biology, activities to broaden access to summer research, and small-group sections and honors laboratories for students in introductory biology.

Washington University

A "pathway" in the sciences, beginning with a residential program offering laboratory training in molecular biology for students in the summer prior to their freshman year, continuing with programs to foster group study and mentoring among undergraduates, and followed by research opportunities in faculty laboratories.

Faculty Development in the Sciences

Twenty universities will enhance the involvement of faculty in undergraduate science education. The $52.5 million total includes approximately $4.5 million to be used for faculty development in the sciences. Funded activities include programs for university faculty to explore new approaches to undergraduate education in the biosciences and other fields as they relate to biology (Figure 23).

Several institutions will add new faculty positions in areas of the sciences currently underserved in their curricula, including biostatistics, cell physiology, and developmental biology. Funds provide support for equipment and laboratory start-up, undergraduate research assistants, and salary supplementation. Institutions receiving support for new faculty appointments have submitted plans for continuing the positions beyond the period of the Institute's grant (Figure 24).

Curriculum and Laboratory Development and Equipment

A total of $15 million provides support to 40 grantee institutions for science curriculum enhancements, equipment upgrades, and laboratory renewal. These funds will support the development of new introductory, intermediate, and upper-division courses and new undergraduate majors in important areas of modern science. The Institute-supported curricula will emphasize hands-on experimentation using modern equipment and laboratories (Figure 25).

Curriculum development funds will also support the integration of biology with related fields of chemistry, physics, and mathematics. Many institutions will use Institute funds to create interdisciplinary courses and laboratories from the introductory through advanced levels. In addition, a number of pro-

Figure 23

Faculty Development Programs, 1992

Arizona State University

A program to provide university science faculty members, as well as science faculty from local community colleges and teachers from secondary schools, with summer and academic-year workshops on inquiry-based instruction in laboratory science that emphasizes hands-on learning, open-ended experiments, and other techniques.

Brandeis University

Recruitment of a new faculty member in the area of human genetics and molecular biology who would develop new undergraduate courses in genetics and biostatistics and create research opportunities in these areas for students.

Michigan State University

Support for activities to enhance science faculty members' knowledge of instructional technologies, including computers and multi-media systems, and approaches to using these technologies in undergraduate teaching.

University of California, Los Angeles

Establishment of a Center for Research in Science Teaching to provide support to science faculty members developing approaches and materials for undergraduate instruction, involve research faculty in teaching, and serve as a university-wide clearinghouse on undergraduate science education.

West Virginia University

Appointment of two new faculty members from among the fields of cell physiology, developmental biology, and molecular biology; increased collaboration between faculty from the University and Medical School for undergraduate teaching and research; and support for the development of new undergraduate teaching materials.

Figure 24

Faculty Appointments, 1992 Selected Fields

Field	Institution
Biochemistry	Boston University
Cell Biology	West Virginia University
Computational Biology	State University of New York at Binghamton
Developmental Biology	University of Notre Dame
Genetics	Brandeis University
Molecular Biology	Vanderbilt University
Neuroscience	Marquette University

grams will include expanded instruction in data and computational analysis, thereby providing students with exposure to an important component of scientific research.

Precollege and Outreach Programs

At 35 grantee institutions, Institute funds will support collaborative programs with elementary, middle, and high schools and with community and junior colleges. A principal form of outreach will be opportunities for teachers and students at these precollege institutions, many with significant enrollments from underrepresented minority groups, to participate in the research at college and university laboratories (Figure 26).

A total of $12 million will support stipends for teachers and students participating in research and laboratory training activities. A number of programs will provide equipment and materials to enable science teachers to implement new curricula, particularly at rural and innercity schools. Other supported activities include visiting scientist programs, in-service workshops, and degree programs for teachers.

Figure 25

Curriculum and Laboratory Development Programs, 1992

California Institute of Technology

New instruments and laboratory enhancements to expand the use of computers in undergraduate instruction in cell biology, neurobiology, and other areas, and to develop computer-based materials for studying such topics as atomic, macromolecular, and organismic structure, three-dimensional modeling of biological phenomena, and imaging of living tissue.

Harvard University

Development of upper-division undergraduate laboratories emphasizing open-ended experimentation using new models for the study of embryology, genetics, and neuroscience, establishment of a computer graphics molecular modeling laboratory for courses in organic and bio-organic chemistry, and new experiments and video demonstrations for a combined chemistry and physics course.

University of Maryland, College Park

New instructional equipment and support for the development of research-oriented laboratory courses in biochemistry, cell biology, genetics, and neurophysiology with experiments to provide the basis for subsequent independent undergraduate research projects.

University of Michigan, Ann Arbor

Support for new "project laboratory" courses in genetics and molecular biology emphasizing hands-on research, acquisition of equipment for developmental biology, microbiology, and physiology laboratories, and computers for general enhancements in the introductory science curriculum.

University of Notre Dame

A major revision of the core undergraduate science curriculum, to integrate the fields of cell, molecular, and developmental biology, genetics, physiology, and other areas of biology with organic and physical chemistry in a new interdisciplinary program, with laboratory development for the new program.

Figure 26

Precollege and Outreach Programs, 1992

Georgetown University

Science activities for teachers and students at inner-city Washington, D.C., schools to include on-campus research opportunities and summer courses in such areas as genetics and molecular biology for high school teachers, student laboratory experiences, and involvement by undergraduates in the development of science fair projects by junior high students.

Oklahoma State University

Expansion of programs to enrich science education at rural Oklahoma elementary, middle, and high schools, particularly those with significant Native American student enrollments, providing laboratory, classroom, and field training for students, and development of a "footlocker" program to provide laboratory equipment and curricular materials as part of a program to develop biology programs at schools in outlying districts.

University of Nebraska, Lincoln

A program to enhance the recruitment and training of elementary and secondary school teachers in the sciences to provide new teacher courses in contemporary biology developed jointly by the University's School of Biological Sciences and the Teachers College, in-service short courses, and other activities.

Vanderbilt University

A four-year summer program for secondary school science teachers leading to a Master of Science degree to include seminars, laboratories, and thesis research in such areas as cell and molecular biology, developmental biology, and neurobiology.

Washington State University

Laboratory experiences, classroom training, demonstrations, and other activities for students in Washington State middle and high schools, including those with significant enrollments of underrepresented minority students, and research training and supplementary equipment and materials for middle and high school biology teachers, with ongoing teacher networks through an electronic "bulletin board" to communicate new scientific and teaching techniques.

New Undergraduate Program and Grants Competition, 1993

The Institute announced a new phase of its undergraduate science education program for 1993. This new program phase was developed, in part, on the basis of findings from the Institute's ongoing assessments of the undergraduate program. For example, a recurring theme of the 1991 program directors meeting concerned the importance of undergraduate research as a means of attracting and retaining students in the sciences, including women and students from minority groups underrepresented in scientific fields (Figure 27).

The program directors also emphasized at the meeting the key role colleges and universities can play in enriching science education through precollege and outreach programs. A number of presentations focused on activities developed by grantees to provide laboratory and classroom training for students and teachers from elementary and secondary schools as well as from two- and four-year colleges.

Another important source of background for undergraduate program development is the annual progress reports submitted by grantee colleges and universities. Over the four years of the program, undergraduate science departments have underscored in their reports the impact of equipment acquisitions and laboratory development supported by their grants in enabling them to provide their students with instruction in the contemporary biological sciences and other disciplines as they relate to biology. They also draw attention to a critical need for continued support to modernize the undergraduate science infrastructure.

Based on information collected through these assessment activities, the 1993 program includes new guidelines and elements representing changes from previous rounds of competition. Support for undergraduate research, including opportunities for women and underrepresented minority students, remains as a central component in the new undergraduate program. Activities to prepare students for laboratory research and enable them to present their findings will also be supported. In addition, support for precollege and outreach programs in the sciences will continue to be a priority.

Applicant institutions may now request up to the full grant amount for equipment for undergraduate science education. The new program also provides up to 50 percent of the total grant amount for renovation of teaching laboratories. Faculty development and curriculum development in the sciences are no longer included as categories.

The Institute is extending invitations to 185 institutions classified by the Carnegie Foundation for the Advancement of Teaching as public and private Comprehensive Colleges and Universities I and II, Liberal Arts Colleges I and II, and

Figure 27

Undergraduate Biological Sciences Education Program

Program Elements and Guidelines (1988-1992)	Program Elements and Guidelines (1993-1995)
Student and faculty development, supporting undergraduate research experiences, opportunities for women and minority students underrepresented in the sciences, and new faculty appointments, included as program elements	Student research, including opportunities for women and minority students underrepresented in the sciences, retained as program elements
Curriculum and laboratory development, supporting new and revised courses, equipment acquisitions, and laboratory renovations, included as program elements	Equipment and laboratory development, supporting equipment acquisitions and laboratory renovations for undergraduate laboratory courses, retained as program elements
Precollege and outreach programs included as program element	Precollege and outreach programs retained as program element
Support for equipment and laboratory renovation limited to 30 percent of total grant amount	No limitation on funding for equipment and funding for renovation limited to 50 percent of total grant amount
Five-year grant period	Four-year grant period

Figure 28

Undergraduate Biological Sciences Education Program Invited Institutions, 1993

Abilene Christian University, Texas
Albertston College of Idaho
Albion College, Michigan
Albright College, Pennsylvania
Alcorn State University, Mississippi
Allegheny College, Pennsylvania
Alma College, Michigan
Amherst College, Massachusetts
Antioch University, Ohio
Augustana College, Illinois
Augustana College, South Dakota
Austin College, Texas
Barnard College, New York
Bates College, Maine
Beloit College, Wisconsin
Birmingham Southern College, Alabama
Bowdoin College, Maine
Bryn Mawr College, Pennsylvania
Bucknell University, Pennsylvania
California State University, Long Beach
California State University, Los Angeles
California State University, Northridge
Calvin College, Michigan
Canisius College, New York
Carleton College, Minnesota
Carroll College, Montana
Catholic University of Puerto Rico
Centenary College of Louisiana
Centre College, Kentucky
Chicago State University, Illinois
Clark Atlanta University, Georgia
City University of New York - Brooklyn College
City University of New York - City College
City University of New York - Herbert H. Lehman College
City University of New York - Hunter College
City University of New York - Queens College
City University of New York - York College
Colby College, Maine
Colgate University, New York
College of Charleston, South Carolina
College of the Atlantic, Maine
College of the Holy Cross, Massachusetts
College of Wooster, Ohio
Colorado College
Concordia College at Moorhead, Minnesota
Cooper Union, New York
Creighton University, Nebraska
Davidson College, North Carolina
DePauw University, Indiana
Denison University, Ohio
Dickinson College, Pennsylvania
Dillard University, Louisiana
Drew University, New Jersey
Earlham College, Indiana
Eckerd College, Florida
Fairfield University, Connecticut
Fisk University, Tennessee
Florida Agricultural and Mechanical University, Florida
Florida International University, Florida
Fort Lewis College, Colorado
Franklin and Marshall College, Pennsylvania
Furman University, South Carolina
Gannon University, Pennsylvania
Gettysburg College, Pennsylvania
Goshen College, Indiana
Goucher College, Maryland
Grinnell College, Iowa
Gustavus Adolphus College, Minnesota
Hamilton College, New York
Hampden-Sydney College, Virginia
Hampshire College, Massachusetts
Hampton University, Virginia
Harvey Mudd College, California
Haverford College, Pennsylvania
Hendrix College, Arkansas
Hiram College, Ohio
Hobart and William Smith Colleges, New York
Hope College, Michigan
Houghton College, New York
Humboldt State University, California
Illinois Benedictine University, Illinois
Inter-American University, Metropolitan, Puerto Rico
Jackson State University, Mississippi
John Carroll University, Ohio
Juniata College, Pennsylvania
Kalamazoo College, Michigan
Kenyon College, Ohio
King College, Tennessee
Knox College, Illinois
La Salle University, Pennsylvania
Lafayette College, Pennsylvania
Lawrence University, Wisconsin
Lebanon Valley College, Pennsylvania
Lewis and Clark College, Oregon
Lincoln University, Pennsylvania
Long Island University, Brooklyn, New York
Loyola College, Maryland
Loyola Marymount University, California
Luther College, Iowa
Macalester College, Minnesota
Manhattan College, New York
Marlboro College, Vermont
Middlebury College, Vermont
Millsaps College, Mississippi
Morehouse College, Georgia
Morgan State University, Maryland
Mount Holyoke College, Massachusetts
Muhlenberg College, Pennsylvania
Nebraska Wesleyan University, Nebraska
New Mexico Institute of Mining and Technology
North Carolina Central University
Oakwood College, Alabama
Oberlin College, Ohio
Occidental College, California
Ohio Wesleyan University
Oral Roberts University, Oklahoma
Pacific Union College, California
Pomona College, California
Prairie View Agricultural and Mechanical University, Texas
Randolph-Macon Women's College, Virginia
Reed College, Oregon
Rhodes College, Tennessee
Ripon College, Wisconsin
Rose-Hulman Institute of Technology, Indiana
Saint John's College, Maryland
Saint John's University, Minnesota
Saint Joseph's University, Pennsylvania
Saint Lawrence University, New York
Saint Mary's University, San Antonio
Saint Olaf College, Minnesota
San Diego State University, California
Santa Clara University, California
Smith College, Massachusetts
Southern College of Seventh-Day Adventists, Tennessee
Southern University and A&M College at Baton Rouge, Louisiana
Southwestern University, Texas
Spelman College, Georgia
Spring Hill College, Alabama
Swarthmore College, Pennsylvania
Talladega College, Alabama
Tennessee State University
Texas Southern University
Thomas More College, Kentucky
Tougaloo College, Mississippi
Transylvania University, Kentucky
Trinity College, Connecticut
Trinity University, Texas
Tuskegee University, Alabama
Union College, Nebraska
Union College, New York
University of Dallas, Texas
University of Dayton, Ohio
University of Lowell, Massachusetts
University of Puerto Rico, Cayey University College
University of Puerto Rico, Mayaguez Campus
University of Puerto Rico, Rio Piedras Campus
University of Richmond, Virginia
University of Saint Thomas, Minnesota
University of Scranton, Pennsylvania
University of Texas, El Paso
University of Texas, San Antonio
University of the Sacred Heart, Puerto Rico
University of the South, Tennessee
Ursinus College, Pennsylvania
Vassar College, New York
Villanova University, Pennsylvania
Wabash College, Indiana
Wake Forest University, North Carolina
Walla Walla College, Washington
Washington and Jefferson College, Pennsylvania
Washington and Lee University, Virginia
Wellesley College, Massachusetts
Wesleyan University, Connecticut
Western Maryland College
Westminster College, Missouri
Wheaton College, Illinois
Wheeling Jesuit College, West Virginia
Whitman College, Washington
Wilkes College, Pennsylvania
Williams College, Massachusetts
Wittenberg University, Ohio
Wofford College, South Carolina
Worcester Polytechnic Institute, Massachusetts
Xavier University, Ohio
Xavier University of Louisiana

Schools of Engineering and Technology. Institutions receiving Institute awards in 1988 and 1991, and other institutions included in these Carnegie Foundation classifications, were invited to compete for four-year awards (Figure 28).

Institutions were invited on the basis of their records, over the past 10 years, of graduating students who went on to medical school or to obtain Ph.D.'s in the biological sciences, chemistry, physics, or mathematics. Data for this assessment were provided by the Association of American Medical Colleges, the National Research Council of the National Academy of Sciences, and the U.S. Department of Education. In addition, institutions from these Carnegie Foundation classifications with demonstrable records of preparing students from minority groups underrepresented in the sciences for medical school and doctorates in these fields were included (Figure 29). Information based on these data is presented in the Program Assessment section (pages 99-103).

As in the previous competitions, proposals will be reviewed by an external panel of scientists and educators from institutions other than those invited to compete in the 1993 round. The evaluations of the external panel will then be reviewed by an internal Institute committee that will make recommendations to the Institute's Trustees, who authorize funding. Grant awards totaling approximately $27 million will be announced in the summer of 1993.

Figure 29

Assessment Criteria

In 1992, data on approximately 1,200 institutions from the five relevant Carnegie Foundation classifications were analyzed to identify institutions for participation in the Undergraduate Biological Sciences Education Program. Institutions were assessed on the basis of the percentage (calculated with data on total baccalaureate degree production collected by the U.S. Department of Education) and absolute number of graduates from each institution who have:

Matriculated in Medical Schools (1979–1988)

Data Source: Association of American Medical Colleges

Earned Doctorates in Biology (1979–1988)

Data Source: National Research Council of the National Academy of Sciences

Earned Doctorates in Chemistry, Physics, or Mathematics (1979–1988)

Data Source: National Research Council of the National Academy of Sciences

In addition, a number of institutions were invited to participate on the basis of their records of graduating students from minority groups underrepresented in the sciences who have gone on to matriculate in medical school or to earn doctorates in biology, chemistry, physics, or mathematics from 1979-1988.

Figure 30

Undergraduate Biological Sciences Education Program Awards to 181 Colleges and Universities ($175.5 million) by Program Component, 1988-1993

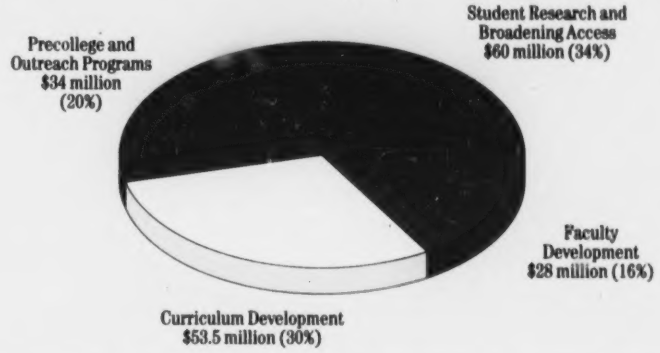


Figure 31

Grantees by Carnegie Foundation Classification, 1988-1992

Carnegie Classification	**Number**
Research Universities I	55
Research Universities II	21
Doctorate-Granting Universities I	11
Doctorate-Granting Universities II	5
Comprehensive Universities and Colleges I	20
Comprehensive Universities and Colleges II	3
Liberal Arts Colleges I	56
Liberal Arts Colleges II	8
Schools of Engineering and Technology	2

Undergraduate Science Education Program—Overview, 1988–1992

Since 1988 the Institute has provided a total of $175.5 million to 181 institutions for five-year grants to support undergraduate science education. In doing so, the Institute has encouraged institutions to develop programs that respond to their particular needs and strengths. Accordingly, the undergraduate program supports a range of activities in numerous scientific disciplines at participating institutions. These include programs for student, faculty, and curriculum development and for precollege and outreach projects (Figures 30 and 31).

In the initial competition held in 1988, the Institute invited 81 private liberal arts colleges and 18 public and private historically black institutions to apply for five-year grants to bolster their science programs. Following review of the 99 proposals by external and internal panels of scientists and educators, 44 institutions, including 34 private four-year colleges and 10 public and private historically black institutions, were awarded a total of $30.4 million in Institute grant support. (For further information on the grants awarded, see *Grants Program Policies and Awards, 1988–1989.*)

In 1989, 101 research and doctorate-granting universities were invited to submit proposals to enhance undergraduate education in biology and related fields. Following review of the proposals, the Institute provided grants totaling $61 million to 51 universities. These awards were paid by the Institute over a two-year period. (See *Grants for Science Education, 1989–1990.*)

In 1991 a total of 98 public and private comprehensive and liberal arts colleges and universities and institutions with demonstrable records of educating underrepresented minority students in the sciences competed for undergraduate awards. Forty-four of these institutions, including 10 with significant records of educating students from minorities underrepresented in the sciences, received grant support totaling $31.5 million for a range of program activities. (See *Grants for Science Education, 1990–1991.*)

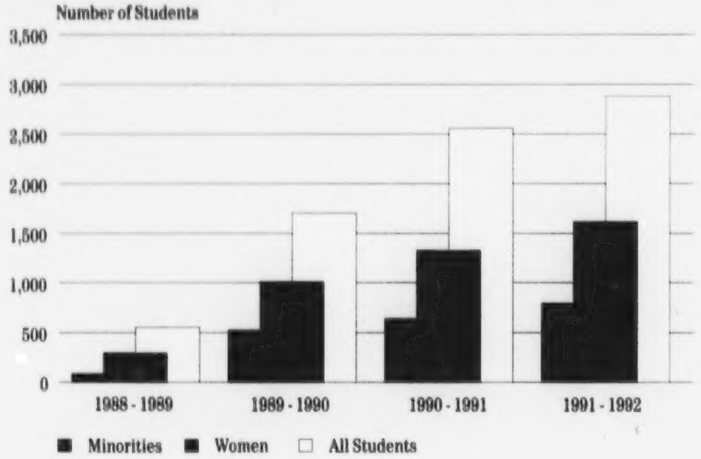
In the fourth competition, held in 1992, 98 research and doctorate-granting universities were invited to submit proposals. The Institute awarded grants totaling $52.5 million to 42 of these institutions. (See pages 43-50 for a list of the grantee institutions and descriptions of their awards.)

The assessment activities carried out since 1988 by the Office of Grants and Special Programs include reviewing annual program reports, preparing publications, organizing meetings, and other special projects. Information collected through these activities indicates that early exposure to laboratory research can play an important role in students' choice of a science major, their academic success, and their

Figure 32

Undergraduate Research, 1988–1992

Student Participation Trends

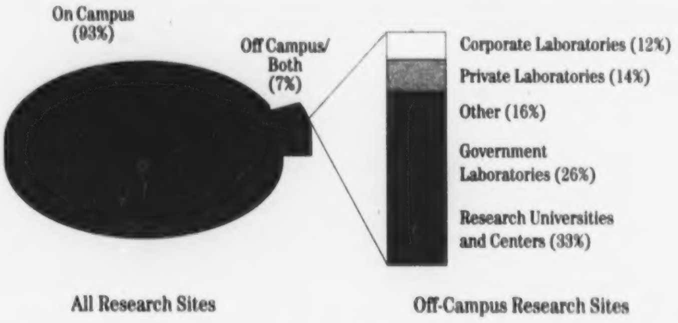


Student Participation-Total

	Total	Percent
All Students	7,820	100%
Minorities	2,039	26
Women	4,261	54

Figure 33

Undergraduate Research Sites, 1988–1992



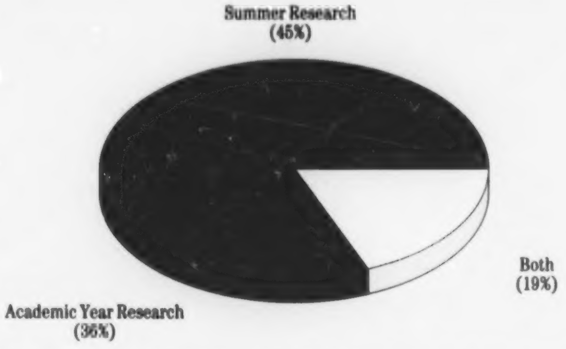
decision to pursue a science career. For example, a number of the students receiving research support through the undergraduate program have gone on to obtain highly competitive Institute predoctoral fellowships, as well as fellowships from the National Science Foundation and other sources. Through ongoing grants programs at colleges and universities and new awards announced in 1992, the Institute continues to support opportunities for undergraduate and precollege students to experience scientific discovery first-hand in research laboratories.

Undergraduate Research, Including Opportunities for Women and Minority Students Underrepresented in the Sciences

Of the total funding of $175.5 million for the undergraduate program, approximately $60 million is being used at 170 institutions for programs to recruit and retain students in the sciences, especially those underrepresented in scientific fields, such as women, blacks, Hispanics, and Native Americans. The principal student activity supported under the program is undergraduate research, providing opportunities for students, many with no prior laboratory experience, to learn scientific concepts, terminology, and techniques while assisting scientists in research projects on or off campus. At a number of institutions, these research experiences have been enhanced when preceded by training activities and followed by opportunities for students to present their research and publish significant findings.

Figure 34

Undergraduate Research by Academic Period, 1988-1992



Since its inception in 1988, the undergraduate program has supported over 7,800 undergraduates conducting research. Of this total, 54 percent are women and 26 percent are students from minority groups underrepresented in scientific fields. Most of the students conducted research with faculty members at their own institutions, and a limited number worked off campus in government laboratories, at other universities or colleges, or in private corporations. The research experiences were evenly divided between the summer and academic year (and some spanned both periods) (Figures 32–34).

Grantee institutions have reported the significant impact of undergraduate research opportunities in attracting student interest in the sciences and helping to retain that interest through the college years and beyond. According to a number of participating students, Institute-supported research experiences have been major factors in their pursuit of scientific training, often through acceptance into outstanding graduate and medical programs and receipt of national fellowships. For example, several undergraduates supported through this program have gone on to receive the Institute's highly competitive predoctoral fellowships.

Faculty Development in the Sciences

Through the undergraduate program, a total of $28 million is being used by 98 awardee institutions for science faculty development, including the appointment of new faculty members, programs to engage research faculty in undergraduate teaching, and other activities. Since 1988, Institute funds have enabled 55 colleges and universities to appoint 114 faculty members in a range of scientific disciplines. The 114 Institute-supported appointments include 50 women (46 percent) and 17 faculty members from minority groups underrepresented in scientific areas (16 percent). These appointments are providing departments with opportunities to develop new courses in important areas of modern science and to update and expand existing curricula (Figure 35).

The scientific disciplines in which Institute-supported faculty

Figure 35

New Faculty Appointments, 1988–1992*

	Total	Percent
Faculty Appointments	114	100
Underrepresented Minorities	17	16
Women	50	46

**Of the 114 Institute-supported appointments, 24 are nontenure track.*

Figure 36

New Faculty Appointments, 1988–1992 Scientific Fields

Field	Number of Appointments
Cell or Molecular Biology	24
Biochemistry/Biophysics	15
Neuroscience	15
General Biology	10
Chemistry	6
Genetics	5
Physics	5
Physiology	4
Other Biological and Scientific Fields	30
Total	114

have been appointed include cell and molecular biology, genetics, and neuroscience. In several cases the new appointments have enabled institutions to bridge science departments, such as biology and chemistry, in the development of interdisciplinary programs. The new faculty members have begun to distinguish themselves at their colleges and universities, which report important contributions in teaching, research, and institutional service (Figure 36).

The Institute provides funds for activities that enrich the current faculty scientists' knowledge of their fields and enhance their ability to convey new knowledge to students. Science faculty members received support to participate in on- and off-campus workshops, seminars, and training programs in the sciences. In addition, a number of faculty received Institute support to attend professional meetings.

Figure 37

Curriculum and Laboratory Development, 1988–1992
Selected Course Areas

Area	Number of Courses
General Biology	200
Chemistry	174
Biochemistry	149
Molecular Biology	139
Cell Biology	125
Neuroscience	120
Physics	62
Physiology	91
Laboratory Techniques	89
Genetics	77
Topics in Biological Sciences	60

Curriculum and Laboratory Development and Equipment

Approximately $53 million has been directed to the development of science curricula and laboratories, enabling nearly all 181 grantee institutions to enhance the quality of instruction in the biological sciences and other disciplines as they relate to biology. Institute grant support in this area is principally directed to the acquisition of modern scientific instrumentation and laboratory renovation. The program also supports the development of new experiments for use in courses, laboratory manuals, and other instructional materials.

Since 1988 the Institute has supported the development of approximately 1,700 courses covering a wide range of scientific disciplines such as genetics, molecular and cell biology, and neuroscience. Approximately 30 fields of biology and other disciplines are represented. Numerous grantee institutions are using their awards to relate biology teaching to chemistry, physics, mathematics, and computer science. In such cases, biological examples are integrated into laboratory courses in the physical sciences and other areas (Figure 37).

Another important objective of the Institute's support of curriculum and laboratory development is the enhancement of opportunities for hands-on laboratory research in undergraduate science courses. Grantee colleges and universities are developing teaching laboratories at the introductory through upper-division levels, providing undergraduates with research experiences that may be continued in faculty laboratories. Institutions report that for many students these research experiences are stimulating interest in science majors and careers.

Precollege and Outreach Programs

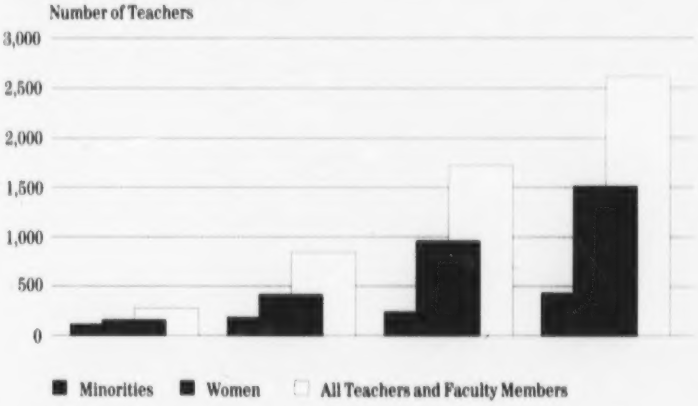
The Institute to date has awarded $34 million to 170 grantee colleges and universities to expand existing linkages and to develop new ones with precollege and other institutions. The objective of these initiatives is to enhance the quality of science programs at these institutions. They are also intended to attract and retain students in the sciences, particularly women and those from underrepresented minority groups.

Programs include summer and academic-year laboratory experiences for teachers and students, summer science camps, equipment loans, curriculum development, and classroom training in biology and chemistry, physics, mathematics, and other areas as they relate to the biological sciences. Approximately 5,500 teachers, of whom 56 percent are women and 19 percent are minority group members, have participated in Institute-supported outreach programs since 1988. In addition, about 16,000 students, including 66 percent minority students and 57 percent women, have

Figure 38

Outreach Program Participants, 1988–1992

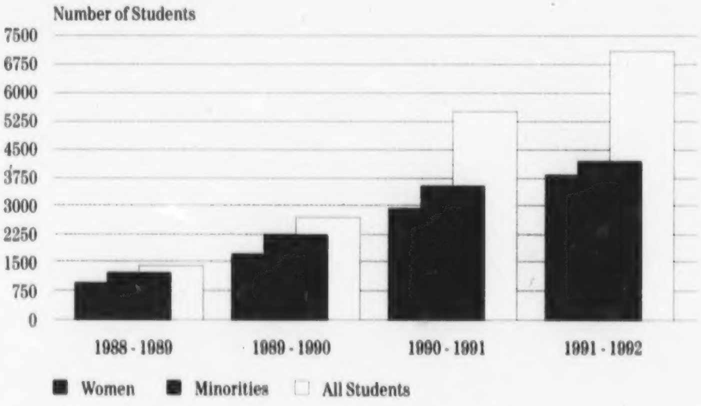
Teacher Participation Trends



Teachers and Faculty Members–Total

	Total	Percent
All Teachers	5,480	100
Minorities	1,032	19
Women	3,089	56

Student Participation Trends

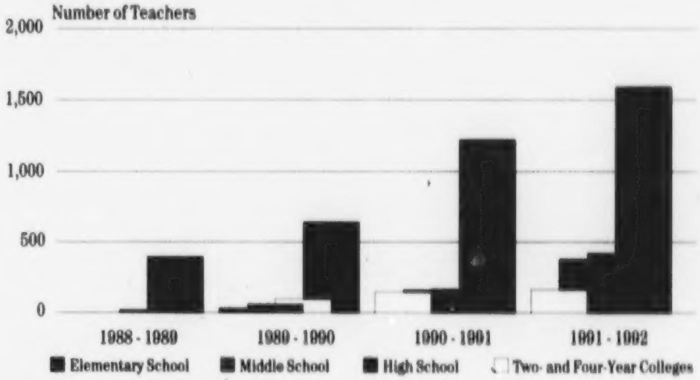


Student Participation–Total

	Total	Percent
All Students	16,009	100
Women	9,151	57
Minorities	10,523	66

Figure 39

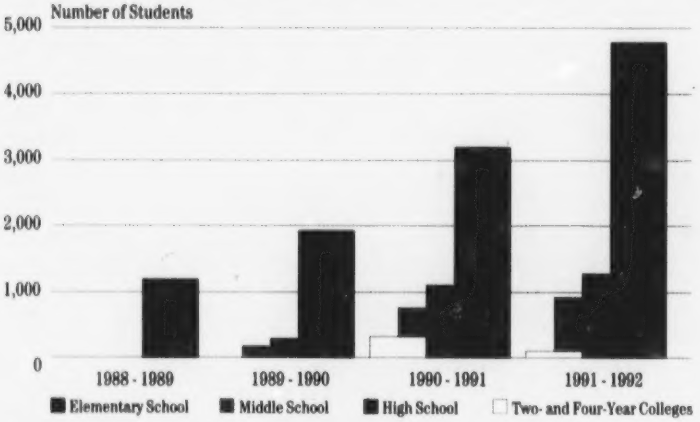
Teacher Participation in Outreach Programs by Teaching Level, 1988-1992



Teacher Participation-Total

	Total	Percent
Elementary School	564	10
Middle School	667	12
High School	3,768	69
Two- and Four-Year Colleges	481	9

Student Participation in Outreach Programs by Education Level, 1988-1992



Student Participation in Outreach Groups-Total

	Total	Percent
Elementary School	2,850	18
Middle School	1,818	11
High School	11,198	70
Two- and Four-Year Colleges	143	1

benefited from these outreach initiatives (Figure 38).

Teachers from elementary, middle, and high schools, faculty members from two-year and four-year colleges, and students from these institutions have been involved in Institute-supported outreach programs. Among the participating teachers, approximately 70 percent have been from high schools. Elementary school and middle school teachers and two- and four-year faculty have also been significantly represented. Among the students 70 percent have also been from high schools. In addition, students at other educational levels have participated (Figure 39).

Colleges and universities have reported on the laboratory activities of precollege students participating in Institute-supported outreach programs. A number of these students have received recognition for their research through programs such as the Westinghouse Science Talent Search and at local, regional, and national science fairs. Many have also been accepted into leading undergraduate science programs. In addition, a number of teachers from elementary and secondary schools have noted improvement in their science teaching as a result of their participation in Institute programs.

Undergraduate Biological Sciences Education Program–1992 Awards

Arizona State University, Tempe, Arizona	$1,500,000
Auburn University, Auburn University, Alabama	1,000,000
Boston University, Boston, Massachusetts	1,000,000
Brandeis University, Waltham, Massachusetts	1,400,000
California Institute of Technology, Pasadena, California	2,000,000
Georgetown University, Washington, D.C.	1,000,000
Harvard University, Cambridge, Massachusetts	1,100,000
Illinois Institute of Technology, Chicago, Illinois	1,000,000
Iowa State University, Ames, Iowa	1,300,000
Kansas State University, Manhattan, Kansas	1,200,000
Marquette University, Milwaukee, Wisconsin	1,200,000
Michigan State University, East Lansing, Michigan	1,200,000
North Carolina State University, Raleigh, North Carolina	1,000,000
Oklahoma State University, Stillwater, Oklahoma	2,000,000
Rutgers, the State University of New Jersey, Newark Campus, Newark, New Jersey	1,200,000
State University of New York at Albany, Albany, New York	1,200,000
State University of New York at Binghamton, Binghamton, New York	1,500,000
Texas Tech University, Lubbock, Texas	1,300,000
University of California–Berkeley, Berkeley, California	2,000,000
University of California–Los Angeles, Los Angeles, California	1,300,000
University of California–Santa Barbara, Santa Barbara, California	1,000,000
University of Cincinnati, Cincinnati, Ohio	1,000,000
University of Delaware, Newark, Delaware	1,000,000
University of Georgia, Athens, Georgia	1,400,000
University of Hawaii at Manoa, Manoa, Hawaii	1,000,000
University of Iowa, Iowa City, Iowa	1,100,000
University of Kentucky, Lexington, Kentucky	1,000,000
University of Maryland, College Park, College Park, Maryland	1,300,000
University of Massachusetts at Amherst, Amherst, Massachusetts	1,200,000
University of Michigan, Ann Arbor, Ann Arbor, Michigan	1,400,000
University of Nebraska–Lincoln, Lincoln, Nebraska	1,000,000
University of Nevada, Reno, Reno, Nevada	1,100,000
University of New Mexico, Albuquerque, New Mexico	1,000,000
University of Notre Dame, Notre Dame, Indiana	1,500,000
University of Oregon, Eugene, Oregon	1,000,000
University of Pittsburgh, Pittsburgh, Pennsylvania	1,700,000
University of Rochester, Rochester, New York	1,000,000
University of South Carolina–Columbia, Columbia, South Carolina	1,000,000
Vanderbilt University, Nashville, Tennessee	1,200,000
Washington State University, Pullman, Washington	1,500,000
Washington University, Saint Louis, Missouri	1,700,000
West Virginia University, Morgantown, West Virginia	1,000,000

Undergraduate Biological Sciences Education Program–1992 Awards Grant Summaries

Arizona State University, Tempe, Arizona
$1,500,000 to support (1) a program to attract and retain students in the sciences, including women and underrepresented minorities, through revision and integration of the core biology curriculum to emphasize student experimentation and discovery, to include the development of new instructional materials and scientific equipment; (2) development of faculty to implement the new curriculum, and opportunities for community college faculty and high school teachers to participate in the curriculum development; and (3) enhanced undergraduate research during the summer and academic year, to include introductory seminars on research concepts and techniques, travel to scientific meetings, and colloquia to present research.

Auburn University, Auburn University, Alabama
$1,000,000 in support of the following activities: (1) development of a minicourse series that focuses on linkages between biology and chemistry for university freshmen and, during the summer, for students from high schools and historically black colleges and universities; (2) summer research opportunities for students and faculty from historically black colleges and for high school students and teachers; and (3) a program to provide hands-on laboratory experiences for undergraduates, particularly women and minorities underrepresented in the sciences.

Boston University, Boston, Massachusetts
$1,000,000 to support (1) summer laboratory experiences, faculty mentoring, and small group workshops on scientific concepts and methods for undergraduates, particularly women and minority students underrepresented in the sciences; (2) appointment of new faculty, to be recruited from among the areas of biochemistry, molecular biology, molecular genetics, and neurobiology; (3) enhancements and integration of undergraduate courses to emphasize hands-on laboratory research and preparation for independent student projects through a pre-research seminar; and (4) outreach to students from inner-city Boston high schools, providing two-year summer and academic-year experiences in University laboratories under faculty supervision.

Brandeis University, Waltham, Massachusetts
$1,400,000 to support the following: (1) development of a new introductory curriculum in the life sciences, integrating biology with chemistry, physics, and mathematics and emphasizing the relationships among the physical and life sciences and quantitative and computational approaches to biology; (2) programs to strengthen the statistical skills of life sciences undergraduates through the appointment of a molecular geneticist with expertise in biostatistics, creation of a computer laboratory, and development of a new course in biostatistics; and (3) increased opportunities for faculty-student research collaboration, including laboratory experiences for students from minority institutions.

California Institute of Technology, Pasadena, California
$2,000,000 to support (1) enhancement of a summer research program for undergraduates, particularly women students, and provision of laboratory experiences for minority students and their faculty research advisers from other institutions; (2) development of computer-based instructional materials (to be made available to other institutions) for undergraduates studying such topics as atomic, macromolecular, and organismic structure, three-dimensional modeling of biological phenomena, and imaging of living tissue; (3) acquisition of new equipment to expand the use of computers for undergraduate instruction in cell biology, neurobiology, and other areas; and (4) expansion of a program that imparts new approaches to teaching biology to teachers in Pasadena-area high schools.

Georgetown University, Washington, D.C.
$1,000,000 to support a program including (1) laboratory and curriculum development, to include new undergraduate concentrations in neurobiology and developmental biology and new experiments and exercises involving computer analysis and microscopy in such disciplines as biochemistry, cell biology, genetics, and physiology; (2) a four-year research "track" for undergraduates, including women and underrepresented minorities, to provide stipends for summer experiences in University and Medical School laboratories, enrollment in research-oriented courses, opportunities to present research, and other activities; and (3) outreach in the sciences to teachers and students in Washington, D.C., high schools, particularly those with significant minority enrollments.

Harvard University, Cambridge, Massachusetts
$1,100,000 to support (1) enhancements in the introductory-level chemistry and physics curriculum and creation of a computer laboratory for modeling macromolecules for a course in organic chemistry; (2) development of the upper-division bioscience curriculum to include new project laboratories in developmental biology, genetics, and neuroscience; (3) research experiences in university and medical school laboratories for undergraduates, particularly women and underrepresented minority students; and (4) activities to enhance high school biology through laboratory experiences for teachers and students, lectures and demonstrations by faculty members, and development of laboratories for advanced placement biology courses.

Illinois Institute of Technology, Chicago, Illinois
$1,000,000 in support of a program to include (1) integration of the biology curriculum with chemistry, physics, and mathematics to provide biology students with a firm background in these areas, and development of undergraduate laboratories in biochemistry, cell biology, and genetics; (2) enhanced recruitment and retention in the sciences of students, particularly women and underrepresented minorities, through stipend support and immersion in interdisciplinary curricula; (3) increased opportunities for students to conduct research within the departments of biology, chemistry, and physics, and at off-campus locations; and (4) outreach activities with Chicago public schools and Chicago-area junior and community colleges.

Iowa State University, Ames, Iowa
$1,300,000 to support (1) a research "track" for undergraduates, including women and underrepresented minority students, to provide laboratory training for first-year students continuing through the senior year; (2) enhancements in the introductory biology curriculum, emphasizing hands-on laboratory research and creation of a resource center in biology instruction for faculty members; (3) programs to broaden access to the sciences including summer research for students from community colleges and other four-year institutions, summer courses for high school biology teachers, and a residential summer research program in University laboratories for high school students.

Kansas State University, Manhattan, Kansas
$1,200,000 to support the following: (1) a program to attract and retain nontraditional students in the sciences, particularly women and underrepresented minorities, to consist of tutorials, academic counseling, stipend support, and research experiences in faculty laboratories; (2) training in molecular biology and genetics for teachers at local and regional secondary schools and community colleges, to include laboratory equipment and supplies to develop new experiments and curricula for their classrooms; and (3) equipment acquisitions and faculty and course development in areas including molecular genetics, virology, microbiology, and immunology and enhancements in mathematics courses.

Marquette University, Milwaukee, Wisconsin
$1,200,000 to support a program including (1) year-long opportunities for undergraduates to assist faculty members conducting research in such areas as biochemistry, mathematics, microbiology, neurobiology, and physiology; (2) enrichment of the biology curriculum to include an undergraduate laboratory for neurobiology and technical support for faculty members teaching undergraduate biology; (3) recruitment of a new faculty member in neurobiology; and (4) a summer workshop program, providing laboratory experiences and other activities in the sciences for middle and high school biology teachers from urban Milwaukee and rural Wisconsin schools with underserved student populations.

Michigan State University, East Lansing, Michigan
$1,200,000 for the following program activities: (1) development of laboratories for new introductory sequences in the biology curriculum, to include courses in general biology, molecular genetics, and developmental biology; (2) expansion of a program to provide students, including those from underrepresented minority groups, with educational support in the biological sciences, chemistry, physics, and mathematics; (3) support for science faculty to enrich teaching skills and expand application of computer and multimedia technologies to teaching; and (4) extended research experiences in faculty laboratories and opportunities to develop new experiments, demonstrations, and instructional materials for kindergarten through high school teachers.

North Carolina State University, Raleigh, North Carolina
$1,000,000 to support (1) summer and academic-year research experiences for undergraduates on campus and in government and private industrial laboratories in neighboring Research Triangle Park; (2) outreach to high school science teachers, particularly those serving rural and minority students, to include interdisciplinary laboratory workshops in biology, chemistry, and physics, development of exercises and materials for classroom use, and laboratory kits and equipment loans to enable teachers to implement the new curricula in their classrooms; and (3) curricular revisions such as integration of biology, chemistry, and physics in introductory courses and a new laboratory in biochemistry and molecular biology.

Oklahoma State University, Stillwater, Oklahoma
$2,000,000 to support (1) development of a research track within the biology curriculum that will provide students at the introductory levels with opportunities for laboratory research and seminars and symposia to present research results; (2) expansion of programs to enrich science education at rural Oklahoma elementary, middle, and high schools, particularly those serving Native American students, providing laboratory, classroom, and field training during the summer; and (3) ongoing linkages with teachers and students during the school year through a "footlocker" program to provide laboratory equipment and curricular materials and through a distance program to develop advanced placement biology at schools in outlying districts.

Rutgers, the State University of New Jersey, Newark Campus, Newark, New Jersey
$1,200,000 to support activities to attract and retain students, particularly those from underrepresented minority groups, in the sciences through (1) summer research experiences for undergraduates in laboratories of faculty members; (2) enhanced student advising and early academic support in the sciences and mathematics; (3) upgrades in biology, chemistry, and physics laboratory courses, with new instrumentation; (4) summer laboratory experiences for science teachers from Newark high schools, including those with significant enrollments of underrepresented minority students, to include ongoing support and opportunities for curriculum development.

State University of New York, Albany University at Albany, Albany, New York
$1,200,000 to support a program to consist of the following: (1) a substantial increase in undergraduate research activity, including pre-laboratory training and experiences in faculty laboratories; (2) creation of a residence hall for science students, with faculty involvement and activities to attract students to the sciences; (3) development of laboratory courses in fields such as bacteriology, cell and molecular biology, organic chemistry, and neurobiology, and creation of a program in computational biology; and (4) expansion of a program to train teachers from Albany-area high schools, including those enrolling significant numbers of minority students, in concepts and techniques of recombinant DNA.

State University of New York, Binghamton, Binghamton, New York
$1,500,000 to support the following: (1) activities to attract and retain students in the sciences, including underrepresented minority students, to include work in laboratories of biology, chemistry, and physics faculty during the summer and academic year; (2) revision of introductory courses to emphasize collaborative research among teams of students working on scientific problems; (3) acquisition of new laboratory equipment and faculty development to implement the curriculum enhancements; and (4) research experiences in University biology, chemistry, and physics laboratories for high school students from New York City and summer workshops in modern biology for teachers from New York State junior high and high schools.

Texas Tech University, Lubbock, Texas
$1,300,000 to support the following components: (1) a significantly expanded undergraduate research program to provide students, including women and Hispanics, with advising on University laboratory opportunities, training in concepts and techniques, faculty-student research collaboration, research colloquia and tutoring, services of an undergraduate research center, travel to scientific meetings, and other activities; (2) summer research opportunities for students from other institutions, including community colleges; (3) laboratory and equipment upgrades; and (4) precollege outreach in the sciences to teachers and students from local and regional schools.

University of California, Berkeley, Berkeley, California
$2,000,000 in support of activities to attract and retain students in the sciences, including (1) a program of seminars, tutoring, and mentoring for students at the introductory levels, including those from underrepresented minority groups; (2) enhancements in upper-division laboratory courses in cell biology, immunology, molecular genetics, neurobiology, and structural biology, with the involvement of senior faculty scientists; and (3) new opportunities for undergraduates to conduct independent research in faculty laboratories during the summer and into the academic year, supplemented by seminars, symposia, and other opportunities to present their research.

University of California, Los Angeles, Los Angeles, California
$1,300,000 to support (1) establishment of departmental centers to provide introductory-level students in biology and the physical sciences, including women and underrepresented minorities, with advising, tutoring, and science career counseling; (2) enhancement of the introductory-level biology course to include new experiments and creation of a new undergraduate neuroscience laboratory; (3) creation of a center for research on teaching to involve science faculty in undergraduate teaching and curriculum development; and (4) opportunities for students from Los Angeles high schools with significant minority enrollments to join University research laboratories in science and engineering, to participate in ongoing workshops in educational and career development throughout the school year.

University of California, Santa Barbara, Santa Barbara, California
$1,000,000 to support the following: (1) activities to attract and retain undergraduates, including women and underrepresented minorities, in the sciences through year-long laboratory experiences with research-active faculty and academic support and tutorials in biology and mathematics; (2) integration of core courses in chemistry, physics, and mathematics to include increased biologically relevant experiments, and enhancements in the laboratory curriculum in such areas as biochemistry, cell and molecular biology, and genetics; and (3) summer laboratory experiences for community college faculty members and high school teachers and development of English and Spanish video presentations for students and parents on biomedical careers.

University of Cincinnati, Cincinnati, Ohio
$1,000,000 in support of the following program components: (1) summer outreach activities for science teachers to include laboratory research, short courses on genetics, immunology, molecular biology, and other areas of modern biology, and other activities, and, for students, summer and academic-year laboratory experiences, weekend seminars, and faculty assistance in developing science fair projects; (2) peer tutoring and stipend support for undergraduates, including underrepresented minority students, in the sciences; (3) equipment and laboratories for courses in microbiology, anatomy, and other areas; and (4) seminars, workshops, and other activities for science faculty development.

University of Delaware, Newark, Delaware
$1,000,000 in support of a program to (1) develop new research-oriented undergraduate laboratories with an interdisciplinary approach to biological problems in molecular biology and biochemistry and computational biophysical chemistry and introduce laboratories in such areas as genetics and molecular biology, physiology, neurobiology, and microbiology; (2) provide stipends for students to conduct independent research in faculty laboratories during summer and winter sessions; (3) increase the recruitment and retention of undergraduates in the sciences, specifically underrepresented minority students, through freshman seminars and a mentoring program.

University of Georgia, Athens, Georgia
$1,400,000 in support of the following: (1) outreach initiatives for teachers and students from junior and senior high schools in rural and urban schools in Georgia, particularly those serving underrepresented minority students, to include summer workshops in mathematics and science for students, activities to encourage participation by students and teachers in science fairs, and a "footlocker" program to lend equipment and supplies to teachers to carry out experiments in the classroom; (2) development of new introductory and upper-division laboratory courses in biochemistry, cell biology, general biology, genetics, and other areas, with equipment for the new laboratories; and (3) undergraduate research experiences, faculty mentoring, and study workshops to encourage students in the sciences.

University of Hawaii at Manoa, Honolulu, Hawaii
$1,000,000 for support of a program to encourage undergraduates, particularly Pacific Islanders and other underrepresented minority students, to pursue advanced study and careers in biomedicine by providing participating students with (1) seminars on laboratory research and career options in biomedical research; (2) initial research experiences with faculty mentors in laboratories at the University, the School of Medicine, and other settings; and (3) continuing research at universities and institutions on the mainland, with opportunities to present research at scientific meetings, visits to other research institutions where students may apply to graduate school, and other activities.

University of Iowa, Iowa City, Iowa
$1,100,000 in support of (1) significant expansion of undergraduate research and related activities, to provide students, particularly women and underrepresented minorities, summer and long-term research experiences in faculty laboratories, peer-assisted learning, and additional student development in the sciences; (2) outreach to junior and senior high schools, extending the University's laboratory resources to teachers and students during the summers and providing classroom presentations at the schools; and (3) integration of introductory-level biology and chemistry courses and enhancements in an intermediate-level laboratory course in cell and molecular biology.

University of Kentucky, Lexington, Kentucky
$1,000,000 to strengthen the recruitment and retention of students in the biological sciences through (1) development of programs to enrich the training of students, including those from Appalachia and underrepresented minority groups, by providing summer and academic-year research experiences and tutorial support at the introductory level; (2) outreach activities for science faculty at Kentucky community colleges to ease the transition of their students to four-year science programs, and laboratory opportunities for high school teachers; and (3) faculty enrichment and development of new courses in cell biology and general biology for non-science majors.

University of Maryland at College Park, College Park, Maryland
$1,300,000 to support (1) development and implementation of upper-division laboratory courses in biochemistry, cell biology, genetics, and neurophysiology, to emphasize hands-on experimentation and encourage student research; (2) acquisition of teaching equipment for the new laboratories; and (3) summer and academic-year research experiences for students, including those from groups underrepresented in the sciences, to follow from students' participation in the research-oriented laboratory courses.

University of Massachusetts, Amherst, Amherst, Massachusetts
$1,200,000 in support of the following: (1) increased laboratory opportunities and programs, such as a science residence hall, to attract to the sciences introductory-level students, particularly women and underrepresented minorities, and summer research for upper-division students in the areas of molecular and cell biology and neuroscience to retain them in the sciences and encourage further study; (2) equipment acquisitions and development of undergraduate laboratory courses in the areas of physical chemistry, molecular and cell biology, and neuroscience; and (3) summer courses and laboratory experiences for community college faculty members and students and high school science teachers.

University of Michigan, Ann Arbor, Ann Arbor, Michigan
$1,400,000 for support of a program to (1) attract and retain students early in their academic careers by providing summer and academic-year laboratory research experiences in the biomedical sciences to first- and second-year undergraduates as well as enhanced advising and tutoring; (2) provide upper-division biology students with in-depth research experience through a new "project laboratory" course offering open-ended investigations in genetics and molecular biology; (3) enhance the use of computer technology in science education for use in student tutorials and other purposes; and (4) upgrade equipment for instructional laboratories in such fields as microbiology, developmental biology and physiology, and establish a new course in neuroscience for nonscientists.

University of Nebraska-Lincoln, Lincoln, Nebraska
$1,000,000 to support the following: (1) a program to enhance the recruitment and training of elementary and secondary school teachers in the sciences, to provide new courses for teachers in contemporary biology developed jointly by the School of Biological Sciences and the Teachers College, in-service minicourses in scientific fields, and other activities; (2) activities to involve undergraduates, including women and underrepresented minority students, in research early in their academic careers through new research-oriented courses, laboratory experiences, and faculty advising; and (3) enhancements in undergraduate laboratory facilities and equipment.

University of Nevada, Reno, Reno, Nevada
$1,100,000 in support of a program to (1) provide undergraduates and high school students with collaborative research experiences during the summer in faculty laboratories, supplemented by seminars and academic and career counseling; (2) offer summer short courses for elementary and secondary teachers to update their knowledge of biology and related disciplines, and enhance the scientific content and laboratory activities in courses for prospective science teachers in the College of Education; (3) involve science and mathematics faculty members in undergraduate education and enrich their teaching skills; and (4) strengthen laboratory and classroom teaching in introductory, intermediate, and upper-division courses in biology and biochemistry.

University of New Mexico, Albuquerque, New Mexico
$1,000,000 in support of a program to include (1) opportunities for undergraduates, including women and black, Hispanic, and Native American students, to pursue laboratory research in the summer and into the academic year, present their research both locally and nationally, and participate in a departmental program on careers in the biomedical sciences, and (2) expansion and enhancement of undergraduate laboratories in cell and molecular biology, including the acquisition of equipment, to include new experiments and an emphasis on hands-on research training.

University of Notre Dame, Notre Dame, Indiana
$1,500,000 to support (1) integration of the fields of cell, molecular, and developmental biology, genetics, physiology, and other areas of biology with organic and physical chemistry and biochemistry, in a new interdisciplinary curriculum, with development of a laboratory for the new program; (2) expansion of undergraduate research opportunities, to emphasize interdisciplinary approaches and provide students training on computer-based data acquisition and analysis; (3) new faculty appointments to implement the interdisciplinary curriculum; and (4) opportunities for biology teachers from urban high schools to earn academic credit and stipends by participating in laboratory research and developing experiments and demonstrations for classroom use.

University of Oregon, Eugene, Oregon
$1,000,000 to support (1) activities to attract and retain students in science, to include research experiences for undergraduates, supplemented by special seminars, opportunities to present and publish research, and peer tutoring; (2) development of computer software for introductory biology and related fields and tutorials in these areas; and (3) summer programs for faculty members and teachers in biology, chemistry, and physics from community colleges and high schools in the Pacific Northwest, and laboratory experiences and opportunities for curriculum development for middle school teachers.

University of Pittsburgh, Pittsburgh, Pennsylvania
$1,700,000 to support a program with the following components: (1) undergraduate research training and experience, to provide students with workshops on research concepts and techniques in biology, summer research in faculty laboratories, activities to broaden access to biology and related disciplines through expanded summer research opportunities for underrepresented minority students, and development of small-group sections and honors laboratories in introductory biology courses; (2) development of the laboratory curriculum through equipment acquisitions, computer enhancements, and new courses in such areas as cell biology, organic chemistry, developmental biology, and neurophysiology; and (3) summer research training for Pittsburgh-area high school students, including those from underrepresented minority groups, and ongoing summer workshops for teachers.

University of Rochester, Rochester, New York
$1,000,000 in support of a program to (1) integrate and strengthen the undergraduate biology curriculum by creating a new introductory-level course sequence, teaching chemistry in the context of biological processes and molecules, relating experiments in organic chemistry to biology, and developing introductory courses on neuroscience and cognitive science; (2) provide undergraduates, including women and underrepresented minority students, with summer and academic-year research experiences; and (3) develop linkages in the sciences with other institutions and bring high school science teachers to the University for research training, laboratory experiences, and development of curricular materials and experiments.

University of South Carolina, Columbia, Columbia, South Carolina
$1,000,000 in support of a program to (1) develop new research-oriented courses in general biology and neurobiology emphasizing experimental design, study of primary literature, laboratory research, data analysis, and presentation of results, and create a teaching laboratory in cell and molecular biology and genetics; (2) provide students, including those from underrepresented minority groups, with laboratory experiences, faculty mentoring, on-campus research symposia, and travel to scientific meetings; and (3) extend outreach in the sciences to local junior and senior high schools.

Vanderbilt University, Nashville, Tennessee
$1,200,000 to support (1) a four-year summer program of seminars, courses, and laboratories in such areas as cell and molecular biology, developmental biology, and neurobiology, and thesis research leading to a Master of Science degree for secondary school science teachers; (2) summer research experiences for University students and undergraduates from other institutions, including those serving underrepresented minority students, with opportunities for students to present their research at scientific meetings; and (3) development of the introductory-level biology and molecular biology curriculum and acquisition of new equipment.

Washington State University, Pullman, Washington
$1,500,000 to support (1) summer and academic-year research experiences for undergraduates in faculty laboratories, with opportunities for students to present their research at University colloquia; (2) a program to provide middle and high school teachers with equipment and supplies to enable them to carry out experiments, demonstrations, and exercises in modern biology in their classrooms, supplementing training they receive at the University, as well as providing an electronic "bulletin board" to communicate new teaching and scientific techniques and other information to the teachers; and (3) laboratory experiences, classroom training, demonstrations, and other activities to attract to biology and related fields students in Washington middle and high schools.

Washington University, Saint Louis, Missouri
$1,700,000 to support (1) activities to increase student access and involvement in the sciences early in their college careers, including summer research opportunities, and a mentoring program and tutoring for introductory-level students; (2) a summer institute in modern biology for teachers from St. Louis high schools, particularly those with significant enrollments of underrepresented minority students, and a prefreshman program in biomedicine providing laboratory training in molecular biology for students from these and other schools; (3) creation of interdisciplinary laboratory courses, including a new general course in the natural sciences, an intermediate genetics course, and upper-division seminars in areas such as structural biology; and (4) development of faculty to implement the new curricula.

West Virginia University, Morgantown, West Virginia
$1,000,000 in support of programs to attract and retain in the sciences underserved students, particularly those from the Appalachian region, to include (1) expansion and enhancement of opportunities for undergraduates to conduct research in faculty laboratories, supplemented by scientific meetings and seminars; (2) appointment of two new faculty members from among the areas of cell physiology, developmental biology, and molecular biology who would develop new undergraduate curricula in these areas; (3) acquisition of teaching instrumentation to equip laboratories for the new courses; and (4) enhancement of public school biology education for secondary school biology teachers in West Virginia through a series of workshops providing hands-on laboratory exercises and other activities.

Precollege and Public Science Education

The Institute is developing initiatives in precollege and public science education to address national concerns about the level of general scientific knowledge and interest among both school-age and adult populations, and to encourage students to choose scientific careers. Among the factors considered in the development of new programs are the major findings of the Institute-supported National Research Council study ***Fulfilling the Promise–Biology Education in the Nation's Schools.*** In addition, new national initiatives in science education and the results of the precollege-oriented outreach activities currently supported under the Institute's undergraduate science education program have been taken into account.

The NRC report lays out an agenda for the scientific community to work with teachers, school administrators, other education professionals, and students at all school levels. The main objectives are to stimulate children's interest in science and to improve science education. A wealth of options are offered for revising curriculum, classroom practices, teacher education (initial and continuing), teacher recruitment, and other concerns in biology and general science education. The report also urges a greater role for practicing scientists in every aspect of education reform, from textbook development to teacher training.

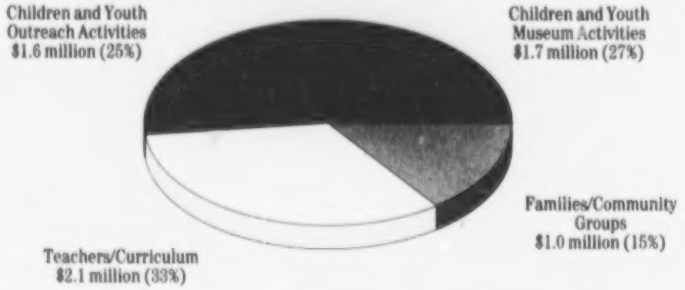
Precollege and Public Science Education Initiative for Museums

In May 1991 the Institute announced a new program in the area of elementary and secondary school education—a precollege science education grants competition for museums. With a major focus on elementary school-age children, this initiative complements the precollege outreach activities funded by the Institute through the undergraduate science education program, which have been geared primarily to secondary school students and teachers. It is intended to further the efforts of museums in developing science education programs for children and youth, for teachers, and for families and community groups.

As noted in the NRC report, natural history museums, zoos, and other institutions (hereinafter referred to collectively as museums) offer a variety of education programs to children on topics related to organismal biology, ecology, genetics, and evolution—many of the subject areas recommended by the NRC for emphasis in the early and middle school grades. In addition, institutions such as children's and youth museums and science and technology centers employ interactive exhibits to foster certain types of learning styles (e.g., curiosity-motivated and exploratory learning) that are not easily nurtured in formal school settings.

Figure 40

Precollege and Public Science Education Initiative for Museums Awards to 29 Museums ($6.4 million) by Program Component, 1992



Many museums also train teachers and assist them in instructing their students to develop problem-solving skills and curiosity in settings where they can enjoy learning through exploration. Further, these institutions play significant roles in stimulating parental and community involvement in the science education of children and youth. Among the activities of particular interest to the Institute are those that involve disadvantaged and underserved minority youth and those that bring museum resources to families and youth groups in rural and urban areas with limited science resources.

Awards, 1992

Under this program a total of $6.4 million in grants was awarded in June 1992 to 29 institutions. Recipients included children's and youth museums, natural history museums, and science and technology centers. These awards were made on the basis of reviews by an external panel consisting of scientists, educators, and museum program experts, with final determinations made by Institute management and Trustees. Over the next five years, these awards will support science activities for children and youth, curriculum enhancement, and teacher training, with special attention to minority and disadvantaged populations in both rural and urban areas (Figure 40).

Children and Youth Programs

The 1992 grants to museums are supporting programs designed to enhance young people's interest in biology and related disciplines and their understanding of these fields. All the projects encourage the participation of girls and of minorities underrepresented in the sciences. Of the $6.4 million, $3.5 million is dedicated to museum-related activities for children and youth. Among the approaches being supported are those that encourage the involvement of students in after-school and summer science activities, including educational programs that ease the transition of underserved minority youth from elementary to secondary school, and programs for youth in both rural and urban areas.

A number of the funded proposals involve organized collaborations between museums and schools, with activities taking place at either site (e.g., field trips, classes, demonstrations, loans of materials, exhibits or artifacts, and sponsorship of science clubs). Another significant focus is on projects that involve students in a variety of science-related activities (e.g., research experiences, docent or "explainer" activities, and exhibition-related opportunities) over a number of years, beginning in elementary school and continuing through the secondary school years. In many of these programs, efforts will be made to involve older children in teaching science to younger children (Figure 41).

Figure 41

Children and Youth Programs

Cleveland Children's Museum, Cleveland, Ohio

"Children Learning About Science and Self (CLASS)," a science outreach effort for kindergarten through third grade teachers, will augment the "hands-on" science curriculum newly adopted by the Cleveland public elementary schools. Several area museums and scientists from the Northeastern Ohio University College of Medicine will be involved. School grounds will be used as field sites for learning environmental and ecological topics.

Scotia–Glenville Children's Museum, Scotia, New York

Natural science programs for kindergarten through third grade students will be taken to inner city Schenectady elementary schools. Activities will be designed to develop observational, analytical, and experimental design skills.

American Museum of Natural History, New York, New York

A two-year laboratory-based program and science colloquia series for minority high school students from New York City public schools will be developed in collaboration with Columbia University's Lamont-Doherty Geological Observatory and the Columbia College of Physicians and Surgeons. Laboratory work will emphasize field-based studies in ecology and the development of analytical skills using computers.

Fernbank Museums, Atlanta, Georgia

Rising seventh graders from inner city and rural school districts will live for four weeks at nearby Emory University while participating in an intensive summer laboratory program in the life and health sciences at the Museum. In addition to the laboratory program, students will visit local scientific institutions to learn about scientific career opportunities before their high school curricular paths are chosen.

Figure 42

Teacher Training and Curriculum Enhancement

Buffalo Museum of Science, Buffalo, New York

A set of "hands-on" teaching kits on botany and invertebrate and vertebrate zoology will be developed for teacher training and travel to schools in Buffalo and across New York State. Kits will include materials from the Museum's collections and supporting materials such as lesson plans, equipment, and audiovisuals.

Franklin Institute, Philadelphia, Pennsylvania

Professional training programs will be developed and offered to middle school life science teachers from throughout Pennsylvania. The scientific focus is on the three major themes in the Pennsylvania middle school curriculum—biodiversity, ecology, and heredity.

Montshire Museum of Science, Norwich, Vermont

A six-week natural history-based curriculum that integrates natural history concepts with reading, writing, and music will be developed for use in fourth and fifth grade classrooms in rural Vermont and New Hampshire. The curriculum emphasizes processes and skills such as observation, comparison, measuring, hypothesizing, and investigating.

Museum of Science and Industry, Chicago, Illinois

An interactive education program for students and teachers in grades four through eight, entitled "Mystery at the Museum," will be created to enhance a major new exhibit called "Imaging Science." Students will work in teams in a laboratory area adjacent to the exhibit to determine the identity of a mystery person, using medical histories and equipment and materials for studying the human body. Follow-up curriculum kits, including microscopes with forensic slides, x-ray film, and other imaging tools will be distributed to teachers to facilitate classroom activities related to the study of the structure and function of the human body.

Teacher Training and Curriculum Enhancement

The Institute's grants initiative for museums is intended, in part, to provide opportunities for pre-service preparation and in-service training for teachers of biology and other disciplines as they relate to biology. Nearly all of the grants awarded in 1992 are supporting some activities involving development or distribution of instructional materials and/or teacher training, with the primary focus on in-service activities. Of the $6.4 million, $2.1 million is dedicated to teacher- and curriculum-related activities. With support from the Institute grants, a significant number of museums will develop inquiry-based instructional materials and kits, with an emphasis on distribution to teachers working in rural and urban areas with limited resources. In many cases, the Institute's grant funds are being used to support biology educators at the museums to maintain and establish precollege science education programs (Figure 42).

Family and Community-Oriented Programs

Recognizing that parental and community awareness of, and involvement in, science education will foster the scientific interests of children and youth, the Institute designated family and community-oriented science education activities as a major priority area for the 1992 initiative. Of the $6.4 million, $1.0 million is for family and community group activities. The new grants are supporting a variety of exciting approaches to involving families, youth organizations, and community groups in the educational activities of museums. Some of the projects provide opportunities for parents and other child care providers (e.g., after-school program directors, Girl and Boy Scout leaders) to be involved in learning science with children. Several grants will support outreach efforts that bring museum resources to families and youth groups in rural areas with limited science teaching resources (Figure 43).

Assessment

Evaluation of the science museums initiative will focus on both quantitative and qualitative measures. The numbers and characteristics of participating students, teachers, and families will be tracked for each grant recipient. In addition, efforts will be made to determine more subtle, qualitative, and long-term impacts of the programs, such as levels of interest and involvement in learning science among participating individuals, families, and schools in the general community. Grant recipients will be asked to provide data to assess topics such as changes in attitudes toward science, and whether programs have resulted in increased use of museum resources.

Figure 43

Family and Community-Oriented Programs

Imaginarium, Anchorage, Alaska

Some of the Museum's existing "hands-on" exhibits will be transported to remote Alaskan Indian and Eskimo communities for use in schools and community centers. High school students from Anchorage will work with Museum educators and scientists from the University of Alaska to redesign the exhibits for transport to selected rural communities. Youth from the targeted communities will be selected to assist with exhibitions and to help establish a local Youth Science Corps that will be part of a network of rural youth corps.

Museum of Science and History, Jacksonville, Florida

"Hands-on" biology programs will be provided at both the Museum and community sites for disadvantaged children in kindergarten through sixth grade and their parents. Program participants will be drawn from local churches and youth organizations such as Big Brothers and Big Sisters and the Boys and Girls Clubs of Northeast Florida. Scientists from Jacksonville University and the University of Florida will work with the Museum's educators to develop inquiry-based science activities that "demystify" biology and related sciences.

Oklahoma Museum of Natural History, Norman, Oklahoma

Five small participatory exhibits will be designed for travel to rural schools, regional museums, libraries, and other community institutions throughout Oklahoma and nearby states. Each portable exhibit will use specimens from the Museum's collection, focus on the natural history of the region, and pay attention to cultural issues unique to the regional Native American tribes. Instructional materials for teachers will also be developed, and some relevant equipment will be made available for loan to schools.

University of Nebraska State Museum, Lincoln, Nebraska

Natural science resource units that include classroom activities, equipment, and specimens will be distributed to rural elementary schools throughout Nebraska. A series of units will be developed for each grade level (kindergarten through grade six), and in-service workshops will be provided to teachers to gain experience with resource units.

Figure 44

1993 Precollege Science Education Initiative for Museums

Program Areas

- Families, youth organizations, and community groups
- Children and youth
- Teachers

Goals

- Enhancing precollege education in biology and related fields
- Developing programs rich in scientific content that incorporate teaching methods appropriate to the subject matter and the populations to be served
- Increasing interest in science education and research careers among women and minorities, including blacks, Hispanics, Native Americans, and other groups underrepresented in the sciences.

Eligibility

- Among the 170 museums invited by the Institute to submit proposals are:
  - Aquaria
  - Botanical gardens and arboreta
  - Children's and youth museums
  - General science museums
  - Natural history museums
  - Science and technology centers
  - Zoos

Awards

- Approximately $4 million in total grants
- Five-year awards from $100,000 to $500,000
- Grant awards to be announced in August 1993

Grants Competition, 1993

In the fall of 1992 the Institute announced a new competition for 1993 because many superior projects could not be funded in the 1992 competition and other museums (e.g., aquaria, botanical gardens, and zoos) with excellent science education programs were not eligible to compete. The new competition is open to many of the museums that were eligible in 1992 as well as a number of those that were previously not eligible to submit applications.

The 1993 grants competition is open to museums that have been invited by the Institute. Among these are selected aquaria, botanical gardens and arboreta, children's museums, general science museums, natural history museums, science-technology centers, and zoos. The 170 institutions invited to compete under this initiative were selected by the Institute after consultation with numerous experts in the field. Nominations were solicited by the Institute and reviewed by groups of experts in each category represented.

In reviewing the list of potentially eligible museums, reviewers took into consideration factors such as existing relationships with schools or other educational organizations and experience in delivering high-quality science education programs to children, youth, teachers, and families. Further, the Institute examined the results of the 1992 grants competition for science museums and children's museums to identify institutions that did not receive awards but submitted proposals that were highly rated by the external review panel. The combined results of these assessments were considered by the Institute, and on the basis of that review, determinations were made on museums to be invited to submit proposals under the 1993 competition.

As with the 1992 awards, proposals will be evaluated by an external panel of scientists, museum program specialists, science educators, and other individuals with relevant expertise. The advisory panel's evaluations and recommendations will then be reviewed by the Institute management, and recommendations will be made to the Trustees, who authorize funding. It is anticipated that up to $4 million in grants will be awarded under the museums initiative in 1993. All grant awards will be made for a five-year term, and are expected to range from $100,000 to $500,000. Grants will be awarded in August 1993 (Figure 44).

Local Precollege Education Initiatives

In 1992 the Institute awarded three grants for the continuation of precollege life-science education projects initiated over the last several years in the greater Washington, D.C., area, the local community of the Institute headquarters. A primary goal of these local science

Figure 45

Montgomery County Public Schools Student and Teacher Intern Program at the National Institutes of Health (1991–1992)

Participation

- Three teacher-interns and 15 student interns in 1991–1992
- Nearly 80 percent minority students; 80 percent girls

Examples of Student Research Projects in NIH Laboratories

- Golgi Apparatus in Extrajunctional Areas of Rat Muscle Fibers Demonstrated by Electron Microscopy
- Discovering the Mechanisms of Salivary Gland Invasion by Sporozites

Examples of Teacher Research Projects in NIH Laboratories

- In Search of a Gene for Familial Mediterranean Fever
- Identification of Genes that Control Human Tumor Cell Invasion

Figure 46

Cold Spring Harbor Laboratory Biotechnology Program with the Montgomery County Public Schools (1991–1992)

Teacher Training

- Five-day summer workshop for teachers on DNA science, including lectures and laboratories
- School year weekend workshop on follow-up and implementation issues
- Seminars on biotechnology topics given by area scientists

Follow-Up Classroom Activities

- Demonstrations and equipment delivery by program manager
- Teacher-led laboratories using materials delivered to high schools in the "DNA Vector Van"
- Development of new biotechnology curriculum by participating teachers (e.g., modules in microbiology and bioethics)

Figure 47

Howard Hughes Medical Institute Summer Research Fellowship Program at the National Institutes of Health (1991–1992)

Selection

- Students are chosen by a selection committee of senior NIH scientists based on
    - grades
    - SAT scores
    - teacher recommendations
    - involvement in science-related activities
- Applications from minorities and females are strongly encouraged

Summer 1991 Fellows

- 24 first-time (9 juniors, 15 seniors)
- 10 returning (6 seniors, 4 first-year college)

Stipends

- High school students, $2,000
- Returning college students, $2,500

Examples of Student Research Projects in NIH Laboratories

- Mucin Secretion by Cystic Fibrosis Cells
- Modeling the Red Blood Cell
- DNA Repair Deficiency and Cancer Predisposition
- Genetic Regulation of Herpes Simplex Virus One Type Latency

education grants is to increase the interest in science and science-oriented careers of girls and of minorities underrepresented in the sciences.

Two of the 1992 grant awards link area high school students and teachers with biologists at the National Institutes of Health in Bethesda, where participants are involved in intensive research experiences for a full year. The Montgomery County Public Schools Educational Foundation, Inc., received a $150,000 grant in support of a third year of the student and teacher intern program that was initiated in 1990 as a pilot project with support from the Institute. The grant is providing 15 students and 3 teachers from Montgomery County high schools with the opportunity to work in NIH laboratories full time in the summer of 1992 and part time during the 1992–1993 school year.

A grant of $30,000 was also awarded in 1992 to the Foundation for Advanced Education in the Sciences at NIH in support of activities related to the student and teacher intern program. A major portion of the grant is for distribution of a videotape (developed with funds awarded by the Institute in 1991) that tracks the progress of student interns and how their perceptions of science and scientists change over the course of their research experiences (Figure 45).

Under three-year grants to the Cold Spring Harbor Laboratory ($46,500) and the Montgomery County Public Schools Educational

Foundation, Inc. ($173,000), the Institute is supporting week-long biotechnology laboratory training institutes for Montgomery County high school biology teachers. To date, approximately 75 teachers have participated. In addition, the grants provide for multiple sets of equipment for conducting classroom laboratories, using recombinant DNA technology, and a van for transporting the necessary equipment. Under this biotechnology program the teacher-participants are also working to develop curricula and student laboratory exercises on microbiology and bioethics (Figure 46).

The cohort of teachers from Montgomery County is included in an ongoing study of more than 2,600 high school faculty who have been trained in the DNA Science Workshop since 1985 by staff from the DNA Learning Center of the Cold Spring Harbor Laboratory. Preliminary findings from this study, from data collected between 1987 and 1990, suggest that many innovative teachers are taking the lead to retool their schools with equipment and materials for hands-on experiments in molecular biology. A large proportion of former participants are involved in teaching other professionals, making presentations, and conducting demonstrations for groups of teachers from other parts of the country who participated in the same DNA science workshops.

The Institute is also supporting summer research experiences for high school students and undergraduates under the local grants program. Through a five-year grant awarded in 1990 to the Foundation for Advanced Education in the Sciences at NIH, about 35 local high school students each year spend their summers doing biology research in NIH laboratories in Bethesda, Maryland. The grant also enables several of the participants to return to NIH laboratories after their first or subsequent years in college (Figure 47).

A local grant of $25,000 was awarded by the Institute in 1992 to support planning efforts related to the development of a program to train teachers to use the Carnegie Institution of Washington's First Light science curricula. First Light is a hands-on science program for inner-city Washington, D.C., elementary school-age children, developed in part with support from a three-year, $40,000 grant awarded in 1990 (Figure 48).

Figure 48

Carnegie Institution of Washington First Light Science Curricula (1991–1992)

Participation

- 25 students in the 1991 summer program
- 32 third and fourth grade students in the 1991–1992 Saturday morning program

Program Highlights

- Bilingual volunteers assisted in bringing the summer program to children in three different languages.
- Three science productions were offered in the summer of 1991 to over 300 local elementary school children on topics such as the first landing on the moon and the study of fossils.
- Nine teachers in a 14-week graduate level course entitled "Interactive Elementary Science Methods." These teachers also obtained 10 hours of field experience through the First Light Saturday program.

Assessment programs are being developed with the Montgomery County Schools and the National Institutes of Health to collect, analyze, and report key data on participants, both students and teachers. Educational and career outcomes will be tracked primarily through annual surveys and selected interviews for at least five years following participation. (See Program Assessment, page 91.)

Precollege Science Education Initiative for Science Museums–1992 Awards

American Museum of Natural History, New York	$200,000
Ann Arbor Hands-On Museum, Michigan	150,000
Buffalo Museum of Science, New York	475,000
Carter House Natural Science Museum, Redding, California	250,000
Children's Museum, St. Paul, Minnesota	125,000
Cleveland Children's Museum, Ohio	275,000
Cumberland Science Museum, Nashville, Tennessee	225,000
Discovery Center, Ft. Lauderdale, Florida	200,000
Discovery Place of Birmingham, Inc., Birmingham, Alabama	125,000
Fernbank Museums, Atlanta, Georgia	250,000
Franklin Institute, Philadelphia, Pennsylvania	200,000
High Desert Museum, Bend, Oregon	250,000
Imaginarium, Anchorage, Alaska	225,000
Lab 3000, Littleton, Colorado	100,000
Lawrence Hall of Science, Berkeley, California	175,000
Memphis Pink Palace Museum, Tennessee	200,000
Montshire Museum of Science, Norwich, Vermont	225,000
Museum of Science and History, Jacksonville, Florida	175,000
Museum of Science and Industry, Chicago, Illinois	400,000
North Carolina Museum of Life and Science, Durham	175,000
North Museum, Lancaster, Pennsylvania	100,000
Oklahoma Museum of Natural History, Norman, Oklahoma	$225,000
Pacific Science Center, Seattle, Washington	225,000
Santa Fe Children's Museum, New Mexico	200,000
Science Museum of Long Island, Manhasset, New York	250,000
Science Museum of Minnesota, St. Paul, Minnesota	200,000
Scotia–Glenville Children's Museum, Scotia, New York	100,000
University of Nebraska State Museum, Lincoln, Nebraska	500,000
Virginia Tech Museum of Natural History, Blacksburg, Virginia	175,000

Precollege Science Education Initiative for Science Museums–1992 Awards Grant Summaries

American Museum of Natural History, New York, New York
$200,000 to provide an intensive two-year natural science program for urban minority youth. Junior and senior high school students will work in small teams on a biological research project with mentors from the Museum, Columbia University's Lamont Doherty Geological Observatory, and the Columbia College of Physicians and Surgeons.

Each participant will receive a laptop computer for data analysis and related purposes, to keep after completing the program. Students will also participate in a series of science colloquia at Columbia University, where they will meet with scientists in small groups to learn about ongoing research. In order to stimulate their support and encouragement, parents of the student researchers will participate in hands-on science workshops.

Ann Arbor Hands-On Museum, Ann Arbor, Michigan
$150,000 for the Museum to collaborate with the Matthaei Botanical Gardens and Eastern Michigan University to provide hands-on biology activities for pre-kindergarten to fifth grade students. Portable laboratory units and discovery chests will be developed and maintained for loan to schools and other community sites. Workshops will be offered to train teachers in how to use these materials. The scientific theme of the project is the biology of living things—including humans, plants, and animals, their structure, growth, and life cycles.

Buffalo Museum of Science, Buffalo, New York
$475,000 to develop, pilot test, conduct training on, and publish four "hands-on" elementary school teaching kits on botany and invertebrate and vertebrate zoology. The project will produce a set of materials designed for travel to schools to give teachers the resources they need for introducing their students to the study of organisms in their natural habitats. Kits will include live plants and insects, freeze-dried mounts, and other materials from the Museum's collections. Supporting materials such as lesson plans, equipment, games, and audiovisuals will also be provided. In addition to the schools, the kits will be made available to libraries, zoos, aquaria, and other institutions of informal learning across the state.

Carter House Natural Science Museum, Redding, California
$250,000 in support of a multicomponent biology education program to serve fourth through eighth grade school children and teachers in the economically depressed rural communities of the Shasta Cascade mountain region. The two principal program elements are (1) development of seven biology units, using local plants and animals to explore biological concepts (e.g., habitat, homeostasis, food webs, and genetic and environmental variation) in depth, and (2) a teacher training component, through which the Museum's education team will go directly to schools in remote locations for one week to train teachers on how to use the seven biology units. Associated program activities will include a traveling science carnival that will visit 40 remote communities to provide demonstrations and activities for families, and a museum naturalist program for teenage volunteers, who will assist in exhibit preparation and demonstrations for the traveling carnival.

Children's Museum, St. Paul, Minnesota
$125,000 in support of a project called "Water, Ni-bi', H_2O," through which biology curricula will be created for first through sixth grade Native American students and their families. The purpose of the project is to create bridges between Native American culture and the study of science so that more Native American children will pursue scientific interests. A curriculum will be developed that connects biological and chemical experiments involving water with Native American tribal stories about water. The curriculum will address the development of problem-solving skills through observation, measurement, and data analysis, and will consist of written guides for teachers and resource kits with scientific equipment, books, and directions for conducting specific scientific activities.

The project will begin with a series of five "Water, Ni-bi', H_2O" camps for Native American children and their families across the state of Minnesota. The Museum's staff and the families will exchange knowledge and activities. Subsequently, a curriculum guide and resource kit will be developed, focusing on different tribal perspectives and stories. These will be introduced to Native American teachers at summer workshops and will be piloted in eight Native American schools.

Cleveland Children's Museum, Cleveland, Ohio
$275,000 in support of "Children Learning About Science and Self" (CLASS), a collaborative science outreach effort centered on urban ecology, which aims to augment the primary school curriculum of the Cleveland public schools. Among the collaborators are a local nature center, the Great Lakes Museum of Science, Environment, and Technology, and the Northeastern Ohio University College of Medicine. CLASS will be developed to complement the new "hands-on" science curriculum recently adopted in the Cleveland public elementary schools. Lead science teachers for Cleveland's system-wide curriculum project will be invited to participate in four-week summer workshops at the Museum. The workshops will assist these teachers in evaluating and using their own schools as field sites for learning environmental and ecological topics. Participating teachers will then serve as mentors for other teachers and as leaders in developing materials for use in the Cleveland public schools.

Cumberland Science Museum, Nashville, Tennessee
$225,000 in support of the Science Horizon program—a long-term intervention project for disadvantaged children and youth in grades one through seven. Through this project, a child will begin with a limited commitment to the program through participation in outreach activities at a local community center, progress to more extensive involvement through science club membership, and move on to the opportunity to serve as an exhibit explainer or to participate in other programs at the Museum. The program content will deal with connections between the sciences, while focusing primarily on biology. To encourage the children's continued commitment to science learning, parents and caregivers will be involved through take-home activities and family nights at the Museum.

Discovery Center, Ft. Lauderdale, Florida
$200,000 for "ASK to Achieve," an initiative for children in grades three through five. The program encompasses visits to the Museum, school-based outreach programs to reinforce the visits, staff and teacher training, and production of resource kits and a teacher manual for school visits. The Museum has appointed an international advisory panel of scientists, museum specialists, and school teachers, who will oversee the operation of the program in partnership with the Broward County elementary science, mathematics, and technology magnet schools. Each year, each grade level will grapple with a different set of four key words and concepts through a series of hands-on learning experiences. Biology is a significant part of the overall program, but the integration of biology with many aspects of science is the goal.

Discovery Place of Birmingham, Inc., Birmingham, Alabama
$125,000 in support of a collaboration between the Museum, the Southern Research Institute and the Samford University Beeson School of Education, to provide training for kindergarten through third grade teachers from Birmingham schools with largely non-white and economically disadvantaged populations. The plan is to introduce inquiry-based curricula in these lower grades. Each year, one teacher at each grade level from each elementary school in Birmingham will attend four two-day workshops. The workshops will focus on materials and curriculum development and emphasize laboratory visits and discussions with scientists at the Southern Research Institute. Each teacher will come away with a kit of materials and plans for about thirty-five lessons. At the end of the grant period, at least one teacher at each of the kindergarten through third grade levels in each elementary school in Birmingham will have participated in the program. Preservice teachers will also be provided with experience in hands-on science teaching at the Museum under the grant.

Fernbank Museums, Atlanta, Georgia
$250,000 to the Fernbank Museum of Natural History and the Fernbank Science Center (Fernbank Museums) to develop a four-week laboratory-oriented science program for educationally disadvantaged students in the summer before they enter the seventh grade. The program, patterned on a high school model which has been operating for ten years, will draw students from inner city and smaller rural school districts to the new Fernbank Museum of Natural History, where the proposed activities will take place in state-of-the-art instructional laboratory space. Students will board at a nearby Emory University dormitory for the duration of the program. The scientific emphasis will be on life and health sciences with some laboratory-oriented physical sciences. Field trips to regional science resource centers are also planned.

Franklin Institute, Philadelphia, Pennsylvania
$200,000 to develop a biology education initiative for middle-school teachers that will concentrate on three topics central to all middle-school biology curricula in Pennsylvania: ecology, biodiversity, and heredity. The scientific content of the proposed program relates to several of the Museum's exhibits, including BioScience (a large-scale interactive DNA sculpture with devices that illustrate the nature and function of this molecule) and Future Earth (a biotechnology greenhouse that illustrates the potential of applied genetics in the environment and other ecological concepts).

Professional development programs will be delivered to over 500 middle-school life science teachers from Philadelphia public and archdiocesan schools. Under the grant, an intensive summer institute and a series of workshops on inquiry-based learning in the biological sciences will be offered, and an annual biology teacher-overnight program will be established.

High Desert Museum, Bend, Oregon
$250,000 to extend its existing natural history education activities to greater numbers of students and teachers, as well as to families and community child-care providers in rural Eastern Oregon. Among the natural science education activities proposed are a junior volunteer program for youth ages 8 to 17; teacher training in biology, geology, and ecology, focusing on the natural resources of the Intermountain West; science-focused public programs, such as workshops for community child-care providers; and traveling science resource kits for outreach to rural schools. A major part of the proposal is to hire a science education staff person to oversee the delivery of programs to the expanded target audience.

Imaginarium, Anchorage, Alaska
$225,000 in support of an outreach program designed around small exhibits selected from the Museum's facility and modified with the addition of curriculum materials for delivery by air to three communities in Alaska that are not accessible by road. Scientists from the University of Alaska at Anchorage will assist in developing the scientific content of the curriculum materials.

Biology topics will include entomology, arctic biology, and health and wellness. One teacher from each of the three participating communities will take part in a two-week workshop in Anchorage and serve over the following school year as the local science resource person for the exhibits. Student interns from Anchorage secondary schools will work at the Imaginarium to help build the small traveling exhibits. In addition, an Alaskan Indian and Eskimo youth Science Corps will be established within each of the participating communities. The Corps will help present the exhibit program in their community, have ongoing access to a communications network linkage with the Imaginarium, and opportunities to network with Corps members in other rural communities.

Lab 3000, Littleton, Colorado
$100,000 in support of a project called Bio-Venture—an outreach program for rural communities in Colorado. The essence of the project is that teams of high school students with a significant percentage of minorities will research, conceive, design, and produce small interactive exhibits that will be transported across the state to host sites including local schools, Rotary clubs, Scout groups, and PTAs. Student exhibit developers will be mentored by college-level biology education students. Another component of the project is the development of elementary and secondary school teaching kits for use with the student-developed exhibits. The scientific content of the project will be determined with technical advice from university faculty and industry experts who are part of the Colorado Alliance for Science.

Lawrence Hall of Science, Berkeley, California
$175,000 to bring activity-based life sciences programs to children, educators, parents, and the public. Building on existing programs, the Museum will create activities and materials on the theme "Healthy Body–Healthy Environment," to engage the audience in the process of scientific inquiry.

The project includes three initiatives: (1) Science Fundays will present hands-on activities for children and their families at the Museum, community festivals, and in schools. A key component of the Science Fundays initiative is the Youth Training Program, which will provide internship opportunities for adolescents who will serve as facilitators for Fundays and other programs. (2) Teacher education workshops and instructional materials will be provided to early elementary educators, child care providers, and Head Start teachers. (3) A community outreach initiative will deliver "Healthy Body–Healthy Environment" activities to schools serving educationally disadvantaged populations.

The Healthy Body–Healthy Environment project will provide a coordinated program of activities with components for multiple segments of a diverse audience. The proposed programs will serve educationally impoverished children, families, communities, and schools through collaborations with Oakland Head Start, the Alameda County Office of Education, and the University of California at Berkeley.

Memphis Pink Palace Museum, Memphis, Tennessee

$200,000 to establish the Memphis Science Alliance, a project to create a series of science enrichment programs for children and youth living in two public housing projects. The program design is sequential, with incentives and awards for children to continue progressively through the eighth grade. This is a collaborative effort with the Lichterman Nature Center, the Coon Creek Science Center, the Emmanuel Episcopal Center, and Youth Services USA.

Through the Community Partners component, a series of participatory science programs (e.g., kitchen science, dinosaur digs) will be offered at the Emmanuel Center on six consecutive Saturdays each fall and spring. A consecutive series of school-based science laboratories will be offered each year for fourth through sixth grade students at an elementary school attended by the children from the two housing projects. After three years in the program, some of the seventh grade students will serve as mentors for the younger elementary students.

The seventh grade students will assist Museum educators with the Saturday programs and have opportunities to participate in day-long field trips in the Museum and to other sites. By the eighth grade, students who have remained in the program will also be invited to visit local chemical companies and the science departments of local colleges to explore career opportunities. Another component of the project is assistance to elementary and junior high school teachers in developing new approaches to teaching science. The Museum will also recruit a minority staff person to oversee the program and develop plans for sustaining the Alliance over time.

Montshire Museum of Science, Norwich, Vermont

$225,000 to create and pilot test a six-week curriculum which integrates natural history with non-science subjects such as reading and writing, for fourth and fifth grade students in parts of rural Vermont and New Hampshire. Curriculum support materials will be developed and teacher workshops on the curriculum will be provided. The program will emphasize student-centered investigatory learning techniques and will include frequent outdoor activities. The biology emphasis will focus less on content and more on processes and skills such as observation, comparison, measuring, hypothesizing, and testing. Biologists from Dartmouth College will be active collaborators on the project.

Museum of Science and History, Jacksonville, Florida

$175,000 in support of a community-based initiative entitled "Fun Science to Unite Families" (FUN STUF), targeted to disadvantaged and underserved children in kindergarten through grade six and their parents. The proposed program utilizes several techniques for attracting and sustaining family involvement. Some of the youth organizations that have committed to the proposed program include Girls, Inc. (formerly Girls Club of America), Episcopal Child Care and Developmental Centers, Inc., Big Brothers and Big Sisters of Greater Jacksonville, and the Boys and Girls Clubs of Northeast Florida.

Inquiry-based science activities will be designed that "demystify biology and related sciences and demonstrate that biology exists around us in familiar environments." Participants in the program will attend several sessions at a neighborhood venue (e.g., a church) before taking part in a full-day science program at the Museum. Take-home activities will be provided to participants and follow-up opportunities will be available to those who seek them.

Museum of Science and Industry, Chicago, Illinois

$400,000 to create an interactive education program for students and teachers in grades four through eight, entitled "Mystery at the Museum." The program will enhance a major new exhibit called "Imaging Science," which is currently being developed by the Museum in collaboration with the University of Chicago. There are three major elements of the project: (1) the mystery activity, to take place in a laboratory area adjacent to the exhibit, where students, working in teams, will use medical histories of fictitious individuals and equipment and materials for studying the human body to determine the identity of a mystery person, (2) three-hour workshops to familiarize teachers with the "Imaging Science" exhibit and the mystery activities, as well as opportunities for further activities in the classroom, and (3) classroom kits, including microscopes with prepared slides, x-ray films, and models of human bones, which will be loaned to teachers to facilitate classroom activities related to methods of studying the structure and function of the human body.

North Carolina Museum of Life and Science, Durham, North Carolina

$175,000 to establish "BioLinks"—a project linked to several of the Museum's exhibits, including "BodyTech" (a look at the human body in both normal and diseased states) and "Life in a Physical World" (an exploration of biomechanics and a demonstration of how the rules of physics apply to plants and animals). Project components include (1) an "Explainer" program through which minority and economically disadvantaged high school students will be hired to work at the Museum, where they will be stationed at the exhibits to give demonstrations and answer visitors' questions, and (2) Saturday Science events with scientists.

North Museum, Lancaster, Pennsylvania
$100,000 to improve access for Hispanic residents in the Lancaster County area by translating the Museum's programs into Spanish and taking the bilingual versions into classrooms and community centers. The Museum has arranged for presentation space at the Spanish American Civic Association's Community Center. Project elements include science kits for use in elementary school classrooms and at community institutions, and a program through which scientists and college students visit elementary schools. The portable science kits to be developed will include objects such as fossils and bones, with complete lesson plans for conducting laboratories on specific science topics such as anthropology, archaeology, and ornithology.

Oklahoma Museum of Natural History, Norman, Oklahoma
$225,000 to initiate BIOTRACKS—a program to create two sets of four small, portable exhibits for transport to rural and inner-city schools and regional museums in Oklahoma and nearby states. Schools with little or no access to the Museum and significant proportions of minority students, including Native Americans and blacks, will host the traveling exhibits. The educational level to be targeted is fifth through tenth grades. The biological themes to be addressed are ecology, evolution, biodiversity, and energy relationships, with emphasis on the natural history of the region. Each miniature exhibit will have an interactive display, a collection of specimens and objects from the Museum's in-house resources, instructional materials, and scientific apparatus and audiovisual materials, as appropriate. Training in the use of instructional materials developed to go along with the miniature exhibits will be provided for teachers. Program collaborators will include the University of Oklahoma Department of Education, the Oklahoma Department of Wildlife Conservation, the Oklahoma Science Curriculum Review Committee, and the Oklahoma Museums Association.

Pacific Science Center, Seattle, Washington
$225,000 to develop and operate several integrated biology education programs at the Mercer Slough, a 320-acre wetlands preserve in a Seattle suburb. Among the activities will be summer camps for youth, workshops for families, and field trips for school groups. Principal target audiences for the project are minority and disadvantaged populations in Seattle and Bellevue. A range of biology topics will be addressed in the various programs, including wetlands biology, ecosystems, life cycles, zoology, botany, ornithology, entomology, and others. Examples of activities include mapping the wildlife of the slough, identifying habitats, using soil chemistry to predict what plants and animals might be found, and analyzing collected data with computers. The Institute's grant will primarily support the construction and equipping of a small biology laboratory at the Mercer Slough site and scholarships for low income youth to participate in the program activities.

Santa Fe Children's Museum, Santa Fe, New Mexico
$200,000 in support of a collaboration between the Museum and the Life Lab Science Program at the University of California at Santa Cruz to involve children in kindergarten through twelfth grade and their families in a land restoration project. Over the grant period, families and Museum visitors will create a horticulture garden. The goal is to involve whole families in inquiry-based science. Santa Fe families will be recruited from the New Mexico Highway Employees Association, the City of Santa Fe, and Tesuque Pueblo.

Four major elements will comprise the program: (1) "Science Detective Families"—a series of hands-on workshops in the workplace and at the Museum, designed in part to recruit parents who might be interested in involving their families in a more intensive program of activities; (2) a focused research project for groups of families, where the multi-generational group will learn how to set up experiments, modify variables systematically, make measurements, and record and graph data; (3) training for teachers and teen volunteers in support of the research project; and (4) workshops at the Museum site for visitors to see and participate in the results of the focused research project.

Science Museum of Long Island, Manhasset, New York
$250,000 for two outreach programs: (1) science resource rooms to be open part-time in all four elementary schools of the Westbury, Long Island, school district (nearly 90 percent black and Hispanic) and staffed 4 days per week by Museum staff, and (2) weekend and school vacation science programs for children, youth and their parents at the Nassau County African-American Museum. The school-based science resource rooms will have projection microscopes, computers, and other materials for "hands-on" biology, ecology, chemistry, and geology. The activities to be conducted at the African-American Museum will be extensions of those that the Science Museum of Long Island has provided for many years. Other activities that will be available to participants in both programs include marine biology excursions on the Museum's sailboat and other field trips.

Science Museum of Minnesota, St. Paul, Minnesota
$200,000 to support a project called "Science Pathways: Explorations in the Biosciences"—a sequence of enrichment opportunities in biology for children in the fourth through sixth grades. Each year, 25 students will participate in a two-week Urban Ecology Camp, where they will explore biological topics in the urban environment. Camps will be followed up over time with bioscience event days and guided field trips to natural history sites in Minnesota for both parents and children.

One-week training institutes will also be included to guide elementary school teachers in field experiences which they can use to complement classroom experiences. Several teachers from each institute will be offered fellowships to assist in the urban ecology camps. To encourage students to become involved in extracurricular science activities, a program will be established through which students can earn vouchers (e.g., through participation in science fairs, clubs, and volunteering at the Museum) to be redeemed for Museum classes or for obtaining a Museum family membership.

Scotia-Glenville Children's Museum, Scotia, New York
$100,000 to take well-established science programs to kindergarten through third grade students in the inner city of Schenectady, where schools have had limited funds to take advantage of such opportunities. In the past, this traveling museum has provided programs to a primarily suburban audience, because schools in these communities are most frequently able to participate in such fee-for-service programs.

The programs run by the Museum attempt to develop observational, analytical, and experimental design skills in primary school children, while focusing on natural science (e.g., mammals, dinosaurs, and earth science topics). The Museum will also develop and present a community-wide biology event called "Something to Do Day," which will take place during spring vacations, as well as free after-school programs for educationally disadvantaged primary school children and their families.

University of Nebraska State Museum, Lincoln, Nebraska
$500,000 in support of a "Natural Science Museum in School" program with three major components: (1) Through "Science on the Run," hands-on natural science resource units that include classroom activities, equipment and specimens will be distributed to rural kindergarten through sixth grade students throughout Nebraska. About four units will be developed for each grade level, each providing a week of classroom activities related to a single theme. (2) The "Kid Science Reporters" component will create 30-minute videos for broadcast on Nebraska public television. The videos will consist of two 15-minute segments to be aired once per month. The first segment will be designed for use in the classroom, and will include student interviews of scientists, including women and minorities, in their laboratories. The second segment will provide additional training for the teachers who are using the "Science on the Run" units in their classrooms. (3) In-service workshops will be provided to elementary school teachers to gain experience with the activities included in the natural science units and videotaped programs.

Virginia Tech Museum of Natural History, Blacksburg, Virginia
$175,000 to initiate a program called Museum Inquiry-Based Natural History Guides for Teachers (MINTS). The project includes the development of guides to local natural history and the provision of workshops to teachers on how to use the guides. The program's focus will be on elementary school students and teachers in rural Appalachia.

The guides will relate to the natural habitats around the local schools, from the parking lots to the fields. The guides will contain background information on particular biological topics, indicating their relevance to the local area (southwestern Virginia); descriptions of investigative classroom and field activities; and annotated references for students and teachers.

Health Sciences Policy

In considering future grants program development, the Institute plans to explore possible initiatives in the general areas of health sciences policy and bioethics, addressing, for example, the issues of public understanding of science, the impact of technology on society, and the various roles of the public and private sectors in national and international policies related to science and technology.

In 1987 the Institute awarded a grant to the Institute of Medicine (IOM) of the National Academy of Sciences to develop studies and program activities that address a variety of topics in health sciences policy (Figure 49). Research briefings have been held and the proceedings published, highlighting areas of biomedical science that merit increased attention by researchers.

In addition, a series of workshops has been held by the IOM Committee on Technological Innovation in Medicine to identify mechanisms for facilitating the translation of basic biological discoveries into improvements in medical practice. A third subject covered by the IOM under the Institute grant concerns how decisions about science and health policy matters are affected by the level of public understanding of the science and technology involved. The case studies and the IOM committee's analysis of six major biomedical policy issues were published in June 1991, in a book entitled *Biomedical Politics*.

Figure 49

Institute of Medicine Health Sciences Policy Studies

Oversight of Biomedical Research

- Publication of *Advances in Understanding Genetic Changes in Cancer*
- Publication of *Imaging Biological Function*

Facilitating Translation of Research Findings into Clinical Practice

- Continuation of ongoing series of workshops on the factors and policies that influence medical innovation, from conception to dissemination into clinical practice
- Developing plans for a long-term study on surgical innovation

Anticipating Legal, Social, and Ethical Issues Arising with Translation of Science into Health Care

- Publication of *Biomedical Politics*
- Developing plans to evaluate methodologies used in the past to explore legal, social, and ethical issues related to biomedical research, and to make recommendations on a process for examining such issues on an ongoing basis

The studies and reports that result from the grant to the IOM will be used to help guide the Institute's development of grants initiatives in the areas of health sciences policy and bioethics.

International Research Scholars

International Research Scholars Program

In recognition of the contributions of scientists abroad to advances in biomedical science, the Institute launched a limited International Research Scholars Program on an experimental basis. Rather than attempt to extend the current research program of the Institute, in which investigators become Institute employees, the Trustees and management judged that it would be more feasible to use a grant mechanism to support the research of a small number of selected biomedical scientists at institutions abroad. Submission of proposals is by invitation only.

Program Characteristics

The purpose of the International Research Scholars Program is to provide support for the overall research programs of promising scientists who have already made significant contributions to fundamental biomedical research—that is, research directed toward an understanding of basic biological processes and disease mechanisms. The grants support the research of outstanding scientists whose research careers are still developing, rather than those in the later phases of distinguished careers. A scholar must hold a full-time academic or research appointment at a medical school, university, research institution, or other nonprofit scientific institution.

The grants support research expenses and allow considerable flexibility in the allocation of funds within each grant. In addition to direct research costs, the grants are contributing significantly to science education through stipends for students and availability of equipment and supplies. In recognition of the limited research resources available in some circumstances and the importance of the intellectual environment in which the scholars conduct their research, the Institute may decide that a portion of the award is to provide shared resources for the scholars' departments.

Nomination, Application, and Selection Process

Because the initiative is small and experimental in nature, the program is limited to selected countries. Canada and Mexico were chosen as the eligible countries for the first awards in 1991. Eligible countries in the competition for the 1993 awards include the United Kingdom, Australia, and New Zealand. The results of these two competitions are detailed below.

The Institute solicits nominations from Institute investigators and scientific advisers and from other scientists knowledgeable about biomedical research in the eligible countries. Biomedical scientists from universities and medical centers throughout the United States evaluate the eligible nominees, and those rated most highly are invited to apply. The applications, which include a research plan summarizing ongoing or planned work that Institute funding would enhance, are evaluated by the external peer review panel. On the basis of these evaluations and the program goals, the Institute's management selects awards to be recommended to the Trustees for authorization for funding (Figure 50).

Figure 50

International Research Scholars Program and Award Highlights

Grant Terms

- 5 year awards
- Up to $500,000*
  - equipment (40 percent limit)
  - personnel**
  - supplies
  - travel (5 percent limit)
  - indirect costs (10 percent limit)

Eligibility for 1995 Awards

- Selected countries
- Significant fundamental research contributions
- Career still developing
- Full-time academic or research appointment
- No major administrative responsibility
- Not U.S. citizen or permanent resident

1993 Awards

- United Kingdom
  - 21 awards for 22 scientists
  - 12 institutions
  - $10.0 million total
- Australia
  - 5 awards for 5 scientists
  - 4 institutions
  - $2.4 million total
- New Zealand
  - 2 awards for 2 scientists
  - 2 institutions
  - $975,000 total

Continued Awards

- Canada (1991)
  - 11 grants for 14 scientists
  - 7 institutions
  - $5.8 million total
- Mexico (1991)
  - 10 grants for 10 scientists
  - 4 institutions
  - $5 million total

* In some circumstances, the Institute may allocate a portion of the award to the scientist's department, for shared resources

** Technicians, graduate students, postdoctoral associates

Awards

In the second competition, 22 outstanding scientists in the United Kingdom, 5 in Australia, and 2 in New Zealand were designated as scholars, and 28 grants were made to their institutions, ranging from $450,000 to $500,000 each. (One joint grant supports the research of two scholars.) The funding commitment for these awards is $2.7 million annually, for a five-year total of $13.5 million, in addition to the $10.8 million for Canada and Mexico. The 20 individual awards and 1 group award in the initial competition went to 14 leading scientists in Canada and 10 in Mexico.

Grant Activities

The first year was highly productive, with more than 50 articles based on grant-supported research published by the Canadian scholars and 15 by those from Mexico. In addition, summaries of the scholars' grant-supported investigations are published each year in the Institute publications *Research in Progress* and the *Annual Scientific*

Report. During the period of grant support, scholars have been invited to participate each year in an Institute-sponsored scientific meeting in Bethesda, Maryland. Since September 1991, the scholars have exchanged scientific information, heard presentations, and interacted with Institute investigators at these meetings, which provide an extraordinary opportunity to foster research collaborations across national boundaries.

In the first year of the program, the 21 grants provided some stipend support to at least 4 graduate students and 10 postdoctoral associates in Canada. In Mexico, partial stipend support went not only to 16 graduate students and 2 postdoctoral associates but also to 4 undergraduates and 2 faculty-level researchers. In Mexico, a percentage of each award is directed to equipment and other shared departmental resources. The departments reported that these grant funds were used to purchase major equipment, computers, numerous small pieces of equipment, chemicals, and journal subscriptions, and to provide stipends or travel funds for students. The Department of Neurochemistry at the Institute for Cellular Physiology in Mexico City set up a molecular neurobiology laboratory as a shared resource and organized a two-week course entitled Molecular Biology Approaches to Study of the Nervous System, taught by Dr. Eric Barnard of the Medical Research Council, Cambridge, England. Eight students from the department attended the

Figure 51

U.S. and Mexican Science Academies

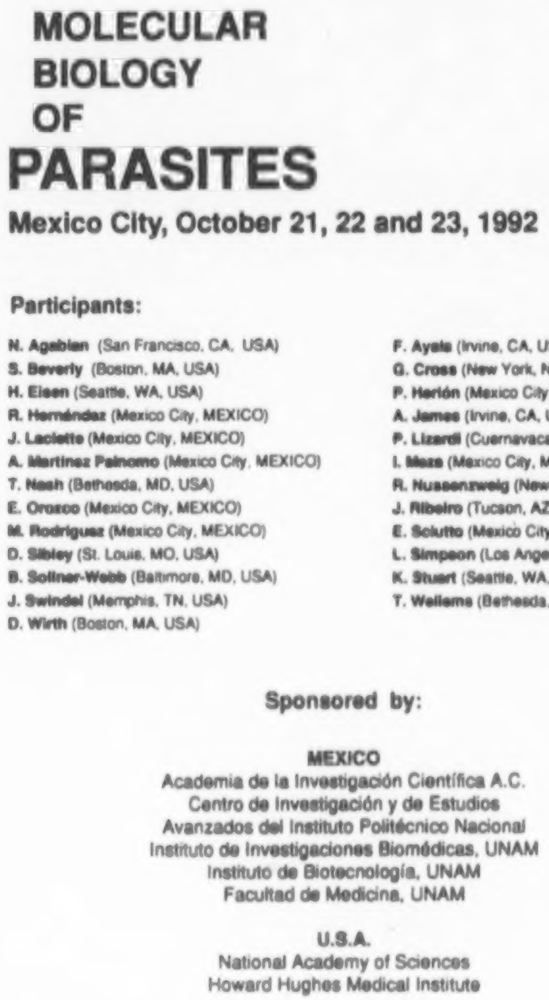
Joint Activities Grants

- Annual symposium in Mexico on biomedical research frontiers
  October 1992:
    Molecular Biology of Parasites, National University of Mexico
- Annual Laboratory Courses
  Summer 1991:
    Methods in Computational Neurosciences
    Dr. James Bower, California Institute of Technology
  Fall 1992:
    Molecular Cloning of Neural Genes
    Dr. James Boulter, Salk Institute for Biological Studies
    Dr. Ricardo Tapia, National University of Mexico

course, in addition to eight from other Latin American institutions.

Figure 52

Announcement of Joint Symposium



MOLECULAR
BIOLOGY
OF
PARASITES

Mexico City, October 21, 22 and 23, 1992

Participants:

N. Agabian (San Francisco, CA, USA)
S. Beverly (Boston, MA, USA)
H. Eisen (Seattle, WA, USA)
R. Hernández (Mexico City, MEXICO)
J. Laclette (Mexico City, MEXICO)
A. Martinez Palomo (Mexico City, MEXICO)
T. Nash (Bethesda, MD, USA)
E. Orozco (Mexico City, MEXICO)
M. Rodriguez (Mexico City, MEXICO)
D. Sibley (St. Louis, MO, USA)
B. Sollner-Webb (Baltimore, MD, USA)
J. Swindel (Memphis, TN, USA)
D. Wirth (Boston, MA, USA)
F. Ayala (Irvine, CA, USA)
G. Cross (New York, NY, USA)
P. Herión (Mexico City, MEXICO)
A. James (Irvine, CA, USA)
P. Lizardi (Cuernavaca, Mor., MEXICO)
I. Meza (Mexico City, MEXICO)
R. Nussenzweig (New York, NY, USA)
J. Ribeiro (Tucson, AZ, USA)
E. Sciutto (Mexico City, MEXICO)
L. Simpson (Los Angeles, CA, USA)
K. Stuart (Seattle, WA, USA)
T. Wellems (Bethesda, MD, USA)

Sponsored by:

MEXICO
Academia de la Investigación Científica A.C.
Centro de Investigación y de Estudios
Avanzados del Instituto Politécnico Nacional
Instituto de Investigaciones Biomédicas, UNAM
Instituto de Biotecnología, UNAM
Facultad de Medicina, UNAM

U.S.A.
National Academy of Sciences
Howard Hughes Medical Institute

Other International Activities

U.S. and Mexican National Academies

In the summer of 1991, the Institute announced grants of $600,000 to the U.S. National Academy of Sciences and $100,000 to the Mexican Academia de la Investigación Científica for joint activities over four years. These activities promote the exchange of scientific information and encourage cooperation between the scientific communities in the two countries, particularly in the life sciences (Figure 51).

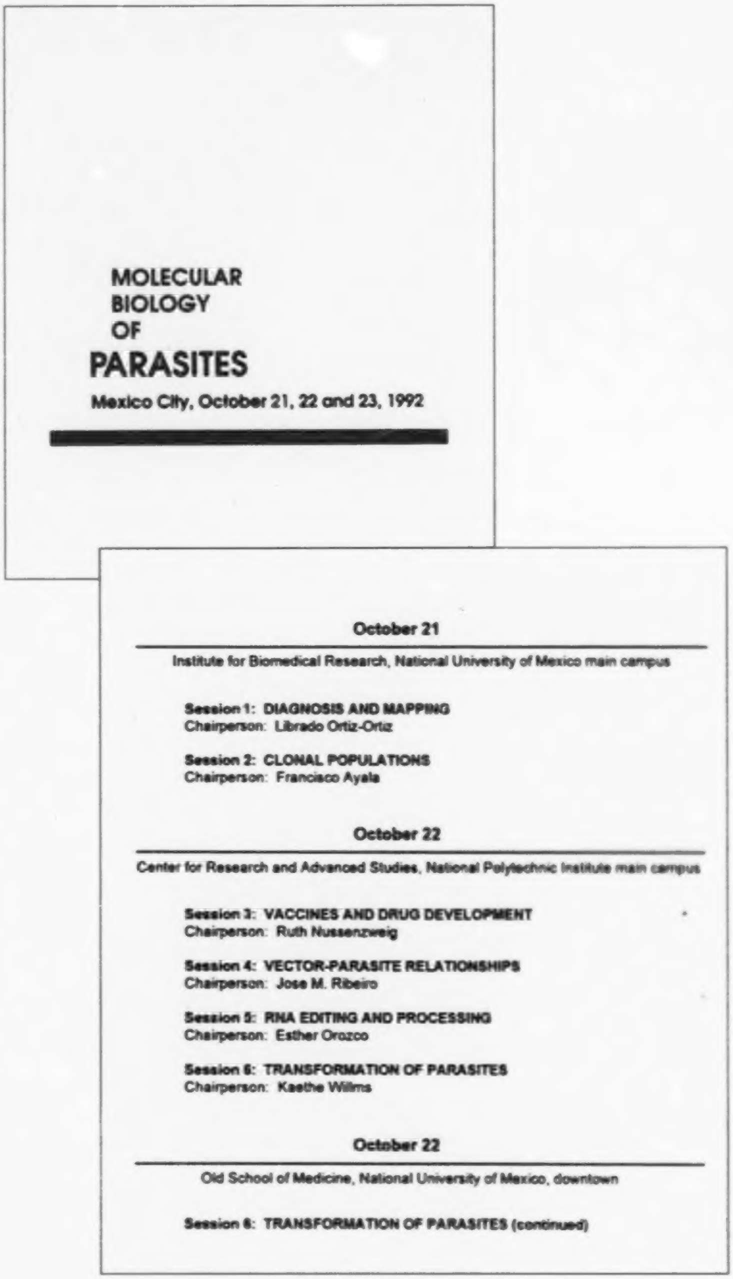
Under the grants to the U.S. and Mexican academies, annual symposia are convened for scientists from both countries for lectures and discussion on research frontiers in the biomedical sciences. A seminar, Molecular Biology of Parasites, was held at the National University of Mexico in October 1992. Sixteen U.S. scientists and eight Mexican scientists made presentations, including two of the international research scholars: Dr. Paul Modesto Lizardi, Institute of Biotechnology, National University of Mexico, and Dr. M. Esther Orozco, Center for Research and Advanced Studies, National Polytechnic Institute (Figures 52 and 53). A four-week lecture series by U.S. researchers on the topic of structural biology is planned for February 1993. In addition, a visiting scientist program sends a U.S. scientist to Mexico for one or two months to participate in research and teaching.

An annual laboratory course, conducted in Mexico City, provides Mexican graduate students, postdoctoral scientists, and more advanced researchers with an opportunity to update their knowledge and laboratory skills. The first laboratory course, Methods in Computational Neurosciences, was offered in the summer of 1991 to 20 participants under the leadership of Dr. James Bower of the California Institute of Technology. The laboratory portion of the course focused on the use of GENESIS, a software program that simulates electrical properties of neural networks. Students used graphic workstations purchased for the course with grant funds. Five of these workstations are now permanently available for the research of scientists at the Center for Advanced Studies of the National Polytechnic Institute in Mexico City, site of the summer course.

The second laboratory course, Molecular Cloning of Neural Genes, was offered in the fall of 1992. This two-week, intensive laboratory and lecture course was directed by Dr. James Boulter of the Salk Institute for Biological Studies and co-organized by Dr. Ricardo Tapia of the National University of Mexico. Introductory lectures on recombinant DNA techniques were enhanced by a comprehensive set of laboratory exercises designed to illustrate the use of specific molecu-

Figure 53

Program for Joint Symposium



MOLECULAR
BIOLOGY
OF
PARASITES
Mexico City, October 21, 22 and 23, 1992

October 21

Institute for Biomedical Research, National University of Mexico main campus

Session 1: DIAGNOSIS AND MAPPING
Chairperson: Librado Ortiz-Ortiz

Session 2: CLONAL POPULATIONS
Chairperson: Francisco Ayala

October 22

Center for Research and Advanced Studies, National Polytechnic Institute main campus

Session 3: VACCINES AND DRUG DEVELOPMENT
Chairperson: Ruth Nussenzweig

Session 4: VECTOR-PARASITE RELATIONSHIPS
Chairperson: Jose M. Ribeiro

Session 5: RNA EDITING AND PROCESSING
Chairperson: Esther Orozco

Session 6: TRANSFORMATION OF PARASITES
Chairperson: Kaethe Willms

October 22

Old School of Medicine, National University of Mexico, downtown

Session 6: TRANSFORMATION OF PARASITES (continued)

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lar cloning techniques. The course also included an evening lecture series by distinguished neuroscientists in an informal setting. (See Figure 54 for a list of the Canadian and Mexican International Research Scholars.)

International Educational Activities

The Institute also supports biomedical research and education internationally through its Research Resources grants. Among the relevant awards are those to the Human Genome Organisation, in support of its Americas Office and related international activities. Awards to the Cold Spring Harbor and Marine Biological Laboratories in support of their series of special courses also benefit the international scientific community. In addition to those from U.S. institutions, students from 16 countries were among the participants in the courses supported by the Institute grants in 1991–1992.

The Institute's graduate education fellowships also have an international component. Among the 294 current predoctoral fellows are 5 U.S. citizens who are pursuing graduate study abroad and 49 graduate students from 21 countries. Further, 8 of the 69 current physician research fellows are citizens of seven countries and 2 are conducting postdoctoral research abroad.

Figure 54

International Research Scholars Program–1991 Awards

Canada

Alan Bernstein, Ph.D.
Head, Division of Molecular and Developmental Biology, and Associate Director, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto
Molecular Genetic Approaches to Hematopoiesis and Development

Barton Brett Finlay, Ph.D.
Assistant Professor, Biotechnology Laboratory and Departments of Biochemistry and Microbiology, University of British Columbia, Vancouver
Host-Pathogen Interactions in Microbial Pathogenesis

Jack Fred Greenblatt, Ph.D.
Professor, Banting and Best Department of Medical Research and Department of Molecular and Medical Genetics, University of Toronto
Transcriptional Regulatory Mechanisms

Sergio Grinstein, Ph.D.
Head, Division of Cell Biology, The Research Institute of the Hospital for Sick Children, Toronto; Professor, Department of Biochemistry, University of Toronto
Ionic Homeostasis in Resting and Activated Leukocytes

Philippe Gros, Ph.D.
Associate Professor, Department of Biochemistry, McGill University, Montreal
The Multidrug Resistance (*mdr*) Efflux Pumps: Structure, Function, Regulation

Alexandra Leigh Joyner, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Associate Professor, Department of Molecular and Medical Genetics, University of Toronto
Targeted Mutagenesis and Molecular Genetic Analysis of Mouse Developmental Genes

James Douglas McGhee, Ph.D.
Professor, Department of Medical Biochemistry, University of Calgary
Control of Lineage-Specific Gene Expression During Early Development

Tim R. Mosmann, Ph.D.
Professor and Chair, Department of Immunology, University of Alberta, Edmonton
Cytokine Functions in Immune Class Regulation

Anthony James Pawson, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto
Biochemical and Genetic Control of Signal Transduction

Randy J. Read, Ph.D.
Assistant Professor, Department of Medical Microbiology and Infectious Diseases, University of Alberta, Edmonton
Protein Crystallography and Rational Drug Design

Janet Rossant, Ph.D.
Senior Scientist, Division of Molecular and Developmental Biology, Samuel Lunenfeld Research Institute of Mount Sinai Hospital, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto
Genetic Control of Cell Lineage Development in the Early Mouse Embryo

Jean-Pierre Roy, M.D.
Assistant Professor, Department of Neurology and Neurosurgery, Montreal Neurological Institute of McGill University
Contribution of Area MSTd to the Spatial Function of the Parietal Cortex

Terry P. Snutch, Ph.D.
Assistant Professor, Biotechnology Laboratory and Division of Neuroscience, University of British Columbia, Vancouver
Molecular Dissection of Neuronal Signal Transduction

Lap-Chee Tsui, Ph.D.
Senior Scientist, Department of Genetics, The Research Institute of the Hospital for Sick Children, Toronto; Professor, Department of Molecular and Medical Genetics, University of Toronto
Molecular Genetics of Cystic Fibrosis and Other Genetic Diseases

Mexico

Carlos Federico Arias, Ph.D.
Associate Professor, Department of Molecular Biology, Institute of Biotechnology, National University of Mexico, Cuernavaca.
Molecular Biology and Epidemiology for the Control of Rotavirus Diarrhea

Edmundo Calva, Ph.D.
Associate Professor and Chairman, Department of Molecular Biology, Institute of Biotechnology, National University of Mexico, Cuernavaca
Molecular Biology of the *S. typhi ompC* and *C. Jejuni ent* Genes

Gabriel Cota, Ph.D.
Investigator, Department of Physiology, Biophysics, and Neurosciences, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City; Adjunct Professor, Department of Biochemistry, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City
Calcium Channels and Hormone Secretion in Pituitary Cells

Alberto Darszon, Ph.D.
Professor, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca
Involvement of Ionic Channels in Sperm Function

Gabriel Guarneros Peña, Ph.D.
Professor, Department of Genetics and Molecular Biology, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City
Control of Bacterial Protein Synthesis by a lambda Phage-Directed Transcript

Luis Rafael Herrera-Estrella, Ph.D.
Professor and Chairman, Department of Plant Genetic Engineering, Center for Research and Advanced Studies, National Polytechnic Institute, Irapuato
Molecular Studies of Two Key Enzymes Involved in Carbon Assimilation in Plants

Paul Modesto Lizardi, Ph.D.
Professor, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca
Simple and Sensitive Assays for the Detection of Human Pathogens

M. Esther Orozco, Ph.D.
Professor, Department of Experimental Pathology, Center for Research and Advanced Studies, National Polytechnic Institute, Mexico City
Entamoeba histolytica: Molecules Involved in Adherence and Damage to the Target Cell

Lourival Domingos Possani, Ph.D.
Professor and Chairman, Department of Biochemistry, Institute of Biotechnology, National University of Mexico, Cuernavaca
Chemical and Functional Characterization of Scorpion Toxins

Ranulfo Romo, M.D., Ph.D.
Professor, Department of Neuroscience, Institute of Cellular Physiology, National University of Mexico, Mexico City
Representations and Transformations of Tactile Signals in Somatic and Frontal Motor Cortices of Behaving Primates

International Research Scholars Program–1992 Awards

United Kingdom

Rosa Susan Beddington, D.Phil.
Senior Group Leader, Agricultural and Food Research Council Centre for Genome Research, University of Edinburgh
The Molecular Basis of Mammalian Gastrulation and Early Organogenesis

Adrian Peter Bird, Ph.D.
Professor of Genetics, Institute of Cell and Molecular Biology, University of Edinburgh
The Biological Significance of DNA Methylation

Gerard Bricogne, Ph.D.
Research Scientist, Senior Grade, Division of Structural Studies, Medical Research Council Laboratory of Molecular Biology, Cambridge
Computational Phasing Methods for Macromolecular Crystallography

Stuart Graham Cull-Candy, Ph.D.
Professor of Pharmacology, University College London, University of London
Amino Acid Receptor Channels and Synaptic Transmission in the Cerebellum.

Christopher Martin Dobson, D.Phil.
University Lecturer, Department of Chemistry, University of Oxford; Deputy Director, Oxford Centre for Molecular Sciences
NMR Studies of Protein Folding and Recognition

Michael Anthony John Ferguson, Ph.D.
Reader in Biochemistry, Medical Sciences Institute, University of Dundee
Structure, Biosynthesis, and Function of Glycosyl-Phosphatidylinositols of the Parasitic Protozoa

Frank G. Grosveld, Ph.D.
Head, Laboratory of Gene Structure and Expression, Medical Research Council National Institute for Medical Research, London
Studies on the Regulation of the Human Beta-Globin Domain

Nicholas Dixon Hastie, Ph.D.
Head, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh
The Role of the Wilms Tumor Gene (*WT1*) in Normal Development and Cancer

Christopher Francis Higgins, Ph.D.
Principal Scientist, Imperial Cancer Research Fund Laboratories, Institute of Molecular Medicine, University of Oxford; Fellow, Keble College, Oxford
The Multidrug Resistance P-Glycoprotein and Related ABC Ion Channels/Transporters

Jonathan Alan Hodgkin, Ph.D.
Staff Scientist, Senior Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge
Molecular and Genetic Analysis of Nematode Sex Determination

David Ish-Horowicz, Ph.D.
Principal Scientist and Head, Developmental Genetics Laboratory, Imperial Cancer Research Fund Developmental Biology Unit, Oxford; Honorary Lecturer, Department of Zoology, University of Oxford
Embryonic Patterning in *Drosophila* by Transcriptional Regulation and Transcript Localization

Alec John Jeffreys, D.Phil.
Royal Society Wolfson Research Professor, Department of Genetics, University of Leicester
Variation and Mutation in the Human Genome

Robert Roger Kay, Ph.D.
Staff Scientist, Senior Grade, Cell Biology Division, Medical Research Council Laboratory of Molecular Biology, Cambridge
Molecular Basis of Pattern Formation in *Dictyostelium*

Roger John Keynes, M.B.B.Chir.
University Lecturer, Department of Anatomy, University of Cambridge
Cell-Cell Repulsion During Neural Development and Regeneration

David Philip Lane, Ph.D.
Professor of Molecular Oncology, Cancer Research Campaign Laboratories, Department of Biochemistry, University of Dundee
The Function of the p53 Tumor Suppressor Gene

Andrew Gino Lumsden, Ph.D.
Professor of Developmental Neurobiology, Division of Anatomy and Cell Biology, United Medical and Dental School, Guy's Hospital, University of London
Cellular and Molecular Mechanisms of Hindbrain Development

Michael Samuel Neuberger, Ph.D.
Senior Scientist, Special Appointment Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge
Expression and Function of the B-Cell Antigen Receptor

Simon Edward Victor Phillips, Ph.D.
Professor of Molecular Biophysics, Department of Biochemistry and Molecular Biology, University of Leeds
Structural Studies of Protein-Nucleic Acid Complexes

James Cuthbert Smith, Ph.D.
Head, Laboratory of Developmental Biology, Medical Research Council National Institute for Medical Research, London
Gradients and Thresholds in the Establishment of the Vertebrate Body Plan.

Alain Robert Townsend, M.B.B.S., Ph.D.
Professor, Department of Clinical Medicine, Institute of Molecular Medicine, University of Oxford
The Biochemistry of Endogenous Antigen Presentation

Richard Henry Treisman, Ph.D.
Principal Scientist, Imperial Cancer Research Fund, London
Transcription Factors in Growth Factor Action

Veronica van Heyningen, D.Phil.
Senior Scientist, Special Appointment Grade, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh; Honorary Fellow, Department of Biochemistry, University of Edinburgh
Molecular, Genetic, and Functional Studies on *PAX6* and Other Aniridia-Associated Genes in the WAGR Region

Australia

David Douglas Lawrence Bowtell, Ph.D.
Wellcome Trust Senior Research Fellow, Howard Florey Institute of Experimental Physiology and Medicine, University of Melbourne
Control of Cellular Differentiation in Mammalian Development

Suzanne Cory, Ph.D.
Senior Principal Research Fellow and Joint Unit Head, Molecular Biology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville
Genetic Control of Hematopoietic Differentiation

Alan Frederick Cowman, Ph.D.
Wellcome Australian Senior Research Fellow, Immunoparasitology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville
Molecular Mechanism of Drug Resistance in Malaria

David James Kemp, Ph.D.
Deputy Director, Menzies School of Health Research, Casuarina
Chromosome Deletions in Relation to Cytoadherence and Gametocytogenesis in *Plasmodium falciparum*

Grant Robert Sutherland, Ph.D., D.Sc.
Director, Department of Cytogenetics and Molecular Genetics, Adelaide Children's Hospital; Affiliate Professor, Department of Pediatrics, University of Adelaide Medical School; Honorary Consultant Geneticist, Queen Victoria Hospital, Adelaide
Studies of the Human Genome: Positional Cloning and Unstable DNA

New Zealand

Edward Neill Baker, Ph.D.
Professor of Biochemistry, Department of Chemistry and Biochemistry, Massey University, Palmerston North
Structural and Functional Analysis of Binding Proteins and Hydrolases

Warren Perry Tate, Ph.D.
Professor of Biochemistry, University of Otago, Dunedin
Translational Stop Signals and Cellular Regulation

International Research Scholars Program–1992 Awards
Biographical Sketches

United Kingdom

Rosa Susan Beddington, D.Phil.

Senior Group Leader, Agricultural and Food Research Council Centre for Genome Research, University of Edinburgh

Dr. Beddington received her D. Phil. in early mammalian development from the University of Oxford in 1981, where she pursued postdoctoral research in the same field. During that period, she also was a Visiting Research Fellow, studying suppression of malignancy at the University of Colorado Health Sciences Center. In 1983 she was appointed Lister Institute for Preventive Medicine Research Fellow at the Sir William Dunn School of Pathology and ICRF Developmental Biology Unit, University of Oxford. At the same time, she was a Junior Research Fellow and Lecturer at Brasenose College, Oxford. In 1988 she became ICRF Research Scientist at the Developmental Biology Unit. She moved to her current position in Edinburgh in 1991. Dr. Beddington is Executive Editor of the *Journal of Experimental Zoology*, Associate Editor of *Cell*, and serves on the editorial board of *Development*. The title of the research to be supported by the Howard Hughes Medical Institute grant is "The Molecular Basis of Mammalian Gastrulation and Early Organogenesis." The objective of Dr. Beddington's research is to identify the genetic and molecular mechanisms underlying the establishment of pattern and tissue diversity during the initial organization and development of the mammalian fetus.

Adrian Peter Bird, Ph.D.

Professor of Genetics, Institute of Cell and Molecular Biology, University of Edinburgh

Dr. Bird received his Ph.D. in genetics from the University of Edinburgh in 1971. He did postdoctoral research on gene amplification in the Department of Biology at Yale University, Connecticut, as a Damon Runyon Memorial Fellow, between 1971 and 1973, and then pursued postdoctoral research on gene isolation at the University of Zurich as a Swiss National Fund Fellow. In 1975 he joined the research staff of the MRC Mammalian Genome Unit in Edinburgh, becoming Acting Director of that unit in 1985, and Head of the Structural Studies Section of the MRC Clinical and Population Cytogenetics Unit at Western General Hospital, Edinburgh, in 1987. He spent two years as a Senior Scientist at the Research Institute of Molecular Pathology in Vienna, Austria, after which he assumed the Buchanan Chair of Genetics at the University of Edinburgh. His honors include election to the European Molecular Biology Organization in 1987 and the Royal Society (London) in 1989. Dr. Bird serves on the editorial boards of *Chromosoma* and *Nucleic Acids Research*. The research program to be supported by the Howard Hughes Medical Institute award is titled "The Biological Significance of DNA Methylation." Dr. Bird's studies are directed toward understanding the importance of DNA methylation in the mammalian genome and the effects of this structural modification on gene function.

Gerard Bricogne, Ph.D.

Research Scientist, Senior Grade, Division of Structural Studies, Medical Research Council Laboratory of Molecular Biology, Cambridge

Dr. Bricogne received his Ph.D. in crystallography from the University of Cambridge in 1977, after which he was a Research Fellow at Trinity College, Cambridge. In 1981 he was appointed Assistant Professor of Biochemistry at Columbia University, New York. In 1983 he became Senior Staff Scientist at the French Synchrotron Radiation Facility in Orsay, France. He assumed his current appointment at the MRC in 1988. His honors include the Lamport Prize for Excellence in Basic Scientific Research from Columbia University in 1983, the Grand Prix Le Bel de la Société Chimique de France, the Prix Grammaticakis-Neumann of the French Academy of Science in 1985, and the Tage Erlander Guest Professorship of the Swedish Natural Science Research Council in 1992. He also was elected to the European Molecular Biology Organization in 1988. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Computational Phasing Methods for Macromolecular Crystallography." Dr. Bricogne's research is directed toward developing computerized mathematical approaches, based on fundamental statistical theory, to determine the structure of large, biologically important molecules.

Stuart Graham Cull-Candy, Ph.D.

Professor of Pharmacology, University College London, University of London

Dr. Cull-Candy received his Ph.D. in neurophysiology from the University of Glasgow in 1974, after which he pursued postdoctoral training in that field at the University of Lund, Sweden, and the Department of Biophysics, University College London, as a Royal Society European Exchange Programme Fellow and Beit Memorial Research Fellow, respectively. He went to the Department of Pharmacology at University College London in 1982 as a Wellcome Trust Senior Lecturer, becoming Professor in 1990. Dr. Cull-Candy has served on the editorial boards of the *Journal of Physiology* and the *European Journal of Neuroscience*. The research program to be supported by the Howard Hughes Medical Institute award is titled "Amino Acid Receptor Channels and Synaptic Transmission in the Cerebellum." Dr. Cull-Candy's research is aimed at understanding the role of neurotransmitters in specific nerve cell actions and mechanisms of cell signaling within the central nervous system.

Christopher Martin Dobson, D.Phil.

University Lecturer, Department of Chemistry, University of Oxford; Deputy Director, Oxford Centre for Molecular Sciences

Dr. Dobson received his D.Phil. in chemistry from the University of Oxford in 1976, after which he was an IBM Research Fellow at the University of Oxford. He was appointed Assistant Professor of Chemistry at Harvard University, Massachusetts, and Visiting Scientist at the Massachusetts Institute of Technology in 1977. He returned to the United Kingdom to assume his present position as University Lecturer in 1980. He is also Official Fellow and Tutor, Lady Margaret Hall, and Lecturer, Brasenose College. Dr. Dobson's honors include the 1983 Corday Morgan Medal and Prize of the Royal Society of Chemistry. The research program to be supported by the Howard Hughes Medical Institute grant is titled "NMR Studies of Protein Folding and Recognition." The primary objective of Dr. Dobson's research project is to provide a description, at a molecular level, of the events that take place during the folding of proteins, and to extend our understanding of interactions between proteins.

Michael Anthony John Ferguson, Ph.D.

Reader in Biochemistry, Medical Sciences Institute, University of Dundee

Dr. Ferguson received his Ph.D. in biochemistry from the University of London in 1982, after which he pursued postdoctoral research in molecular parasitology at Rockefeller University, New York, from 1982 to 1985, and then in the field of carbohydrate structure at the University of Oxford. In 1988 he joined the Department of Biochemistry, University of Dundee, as Lecturer, and assumed his current position as Reader in 1991. His honors include the Colworth Medal from the Biochemical Society in 1991. He also serves on the editorial boards of *Biochimica et Biophysica Acta*, *Biochemical Journal*, and *Molecular and Biochemical Parasitology*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "Structure, Biosynthesis, and Function of Glycosyl-phosphatidylinositols of the Parasitic Protozoa." The long-term objective of Dr. Ferguson's research is to understand sufficiently the relationship between the cell surface of parasitic protozoa and their life cycles to provide new insights into development of therapeutic agents and vaccines against parasitic diseases.

Frank G. Grosveld, Ph.D.

Head, Laboratory of Gene Structure and Expression, Medical Research Council, National Institute for Medical Research, London

Dr. Grosveld received his Ph.D. in the field of biochemistry from McGill University, Montreal, in 1976, after which he pursued postdoctoral research training in molecular biology at the University of Zurich, Switzerland, the University of Amsterdam, and the National Institute for Medical Research, initially as a European Molecular Biology Organization Fellow and then as a Royal Society Fellow. In 1982 he was appointed Acting Head of the Division of Gene Structure and Expression at the National Institute for Medical Research, London, and became Head in 1985. His honors include election to the European Molecular Biology Organization in 1986, the Jeantet Prize in Medicine, 1991, and election to the Royal Society (London) in the same year. The title of the research that will be supported under the award from the Howard Hughes Medical Institute is "Studies on the Regulation of the Human Beta-Globin Domain." The aim of Dr. Grosveld's research is to understand on a molecular level the regulation of human globin genes, with a long-term objective of developing new methods, such as gene therapy, for treatment of thalassemia and sickle-cell anemia.

Nicholas Dixon Hastie, Ph.D.

Head, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh

Dr. Hastie received his Ph.D. in virology from the University of Cambridge in 1973. Subsequent postdoctoral research at the University of Edinburgh focused on expression of mammalian genes. He went to the Roswell Park Memorial Institute, New York, as a Cancer Research Scientist and Assistant Research Professor in 1975, and subsequently became Senior Scientist and Associate Research Professor. In 1982, he was appointed to the scientific staff of the MRC Human Genetics Unit and became Section Head in 1984. Dr. Hastie's honors include election to the European Molecular Biology Organization and the Human Genome Organisation. His editorial board service includes *Analytical Biochemistry*, *British Journal of Cancer*, *Genes and Development*, *Technique*, and *Mammalian Genome*. The Howard Hughes Medical Institute grant will support his research program on "The Role of the Wilms Tumor Gene (*WT1*) in Normal Development and Cancer." The goal of Dr. Hastie's research is to understand the molecular and cellular basis of a human genetic disorder, Wilms tumor of the kidney.

Christopher Francis Higgins, Ph.D.

Principal Scientist, Imperial Cancer Research Fund Laboratories, Institute of Molecular Medicine, University of Oxford; Fellow, Keble College, Oxford

Dr. Higgins received his Ph.D. in the field of plant biochemistry from the University of Durham in 1979. He was then appointed a NATO-SERC Postdoctoral Fellow in the field of microbial molecular genetics, at the University of California, Berkeley. In 1981, he was appointed Lecturer in the Department of Biochemistry at the University of Dundee, assuming the position of Professor of Molecular Genetics in 1988. In 1989 he moved to his current position at the Imperial Cancer Research Fund, Institute of Molecular Medicine, University of Oxford. His honors include the 1987 Fleming Award of the Society for Microbiology and election to the European Molecular Biology Organization in 1989 and the Royal Society of Edinburgh in 1990. Dr. Higgins is the editor-in-chief of *Molecular Microbiology* and serves on the editorial board of *Cell* and other professional journals. The title of the research to be supported under the grant from the Howard Hughes Medical Institute is "The Multidrug Resistance P-Glycoprotein and Related ABC Ion Channels/Transporters." The objective of Dr. Higgins's research is to understand the molecular mechanisms involved in the movement of small molecules across membranes.

Jonathan Alan Hodgkin, Ph.D.

Staff Scientist, Senior Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge

Dr. Hodgkin received his Ph.D. in 1974 in the field of developmental genetics from the University of Cambridge. As a Science Research Council Postdoctoral Research Fellow, he undertook research in bacterial genetics at Stanford University, California, in the Department of Biochemistry. In 1976 he became a scientific staff member at his current institution, receiving a Senior Grade appointment in 1987. Dr. Hodgkin's honors include election to the European Molecular Biology Organization in 1989, the Royal Society (London) in 1990, and the Academia Europaea in 1992. He also serves on the editorial boards of a number of journals, including *Genes and Development*, *Cell*, and *Developmental Genetics*. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Molecular and Genetic Analysis of Nematode Sex Determination." Dr. Hodgkin's research has focused on the use of genetics, developmental biology, and molecular biology to achieve a detailed molecular description of the choice and execution of major developmental decisions, such as sex determination in a nematode worm.

David Ish-Horowicz, Ph.D.

Principal Scientist and Head, Developmental Genetics Laboratory, Imperial Cancer Research Fund Developmental Biology Unit, Oxford; Honorary Lecturer, Department of Zoology, University of Oxford

Dr. Ish-Horowicz received his Ph.D. in the field of molecular biology from the University of Cambridge in 1973, after which he undertook postdoctoral research training in molecular genetics at the Department of Cell Biology, Basel University, Switzerland. In 1977 he joined the staff of the Imperial Cancer Research Fund, London, as a Research Scientist. He was promoted to Senior Research Scientist and Head, Laboratory of Developmental Genetics, in 1981. He then moved to the Imperial Cancer Research Fund Developmental Biology Unit at Oxford in 1985. Honors include election to the European Molecular Biology Organization in 1985 and appointment to the editorial boards of *Genetical Research* and *Cell*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "Embryonic Patterning in *Drosophila* by Transcriptional Regulation and Transcript Localization." This research explores aspects of developmental asymmetry, including the roles of certain proteins in segmentation and in development of nerve cells during the growth of embryos, and genes that influence these processes.

Alec John Jeffreys, D.Phil.

Royal Society Wolfson Research Professor, Department of Genetics, University of Leicester

In 1975 Dr. Jeffreys received the D.Phil. in the field of genetics from the University of Oxford, after which he pursued postdoctoral research training in the analysis of mammalian globin genes at the University of Amsterdam as a European Molecular Biology Organization Research Fellow. In 1977 he was appointed Lecturer in the Department of Genetics of the University of Leicester, becoming Reader in 1984 and Professor in 1987. His honors include the 1985 Colworth Medal for Biochemistry from the Biochemical Society, the 1987 Carter Medal from the Clinical Genetics Society, the 1987 Davy Medal from the Royal Society, and election to the Royal Society in 1986, the International Institute for Biotechnology in 1990, and the Royal College of Pathologists in 1991. Dr. Jeffreys serves as Associate Editor of the *Journal of Molecular Evolution* and on the editorial boards of a number of journals, including *Genetical Research*, *Genomics*, *Molecular Biology and Evolution*, *Nucleic Acids Research*, and *Animal Genetics*. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Variation and Mutation in the Human Genome." The objective of these studies is to understand mechanisms of mutation, evolution, and environmentally induced damage to cells, through analysis of DNA sequence.

Robert Roger Kay, Ph.D.

Staff Scientist, Senior Grade, Cell Biology Division, Medical Research Council Laboratory of Molecular Biology, Cambridge

Dr. Kay received his Ph.D. in 1973 in the field of biochemistry from University College London. He did postdoctoral research in cell biology at the University of Freiburg, Germany, as a European Molecular Biology Organization Postdoctoral Fellow, and in developmental biology at the Imperial Cancer Research Fund, London. He received a staff appointment at the ICRF in 1978 and moved to the MRC Laboratory of Molecular Biology in 1984. Dr. Kay has served on the editorial boards of the *Journal of General Microbiology* and *Development*. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Molecular Basis of Pattern Formation in *Dictyostelium*." Dr. Kay's research is focused on the genetics, cell biology, and biochemistry of differentiation in slime molds.

Roger John Keynes, M.B.B.Chir.

University Lecturer, Department of Anatomy, University of Cambridge

Dr. Keynes received his medical degree from the University of Cambridge after clinical training at the Middlesex Hospital Medical School, London, in 1975. Subsequent to further clinical training he became a Member of the Royal College of Physicians, then undertook an MRC Training Fellowship in neurobiology at The Physiology Laboratory, University of Oxford, in 1979. In 1981 he was appointed University Demonstrator, Department of Anatomy, University of Cambridge, and Lecturer and Director of Studies, Medical Sciences, Trinity College, Cambridge. He assumed his present position as University Lecturer in 1984. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Cell-Cell Repulsion During Neural Development and Regeneration." The objective of Dr. Keynes's research is to understand the mechanisms and role of cell-cell repulsion in normal brain development and the factors influencing failure of regeneration following injury.

David Philip Lane, Ph.D.

Professor of Molecular Oncology, Cancer Research Campaign Laboratories, Department of Biochemistry, University of Dundee

Dr. Lane received his Ph.D. in 1976 in the field of immunology from University College London, after which he undertook postdoctoral research in the field of virology at the Imperial Cancer Research Fund, London. He was then appointed Lecturer in the Zoology Department at the Imperial College of Science and Technology, London, Robertson Research Fellow at the Cold Spring Harbor Laboratory, New York, and Lecturer in the Biochemistry Department of the Imperial College of Science and Technology. He moved to the Imperial Cancer Research Fund, London, in 1985 to become Senior Staff Scientist and then Principal Scientist in 1988. He assumed his current position in 1990. Dr. Lane's honors include election to the European Molecular Biology Organization and the Royal Society of Edinburgh. He is also a Gibb Fellow of the Cancer Research Campaign. Dr. Lane serves on the editorial boards of *Cell*, *Journal of Cell Science,* and *Cancer Surveys*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "The Function of the p53 Tumor Suppressor Gene." The goal of Dr. Lane's research is to develop new treatments based on detailed knowledge of the role of tumor suppressor genes in human cancer.

Andrew Gino Lumsden, Ph.D.

Professor of Developmental Neurobiology, Division of Anatomy and Cell Biology, United Medical and Dental School, Guy's Hospital, University of London

Dr. Lumsden received his Ph.D. in developmental biology from the University of London in 1978. While pursuing graduate study, he was also a Lecturer in Anatomy at Guy's Hospital Medical School. He was promoted to Senior Lecturer, Reader, and, in 1989, Professor of Developmental Neurobiology. His honors include La Medaille de la Ville de Paris in 1986. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Cellular and Molecular Mechanisms of Hindbrain Development." The aim of Dr. Lumsden's research is to determine the cellular and molecular mechanisms that influence the early stages of development and determine when regional patterns are specified and diverse neuronal cell types first become distinct.

Michael Samuel Neuberger, Ph.D.

Senior Scientist, Special Appointment Grade, Medical Research Council Laboratory of Molecular Biology, Cambridge

Dr. Neuberger received his Ph.D. in biochemistry and molecular biology in 1978 from Imperial College, London. For the next two years, he was a Science Research Council Postdoctoral Fellow in the field of molecular genetics, also at Imperial College, University of London, as well as a European Molecular Biology Organization Fellow at the Institute of Genetics, University of Cologne, Germany. He moved to the MRC Laboratory of Molecular Biology in 1980, with promotion to the Senior Scientific Staff in 1988 and to Special Appointment Grade in 1991. In addition, he was appointed Assistant Lecturer and Fellow at Trinity College, Cambridge, in 1985, and Lecturer in Cell Biology and Biochemistry in 1989. His honors include the Max Perutz Prize in 1986, election to the European Molecular Biology Organization in 1989, and appointment to the editorial board of the *European Journal of Immunology*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "Expression and Function of the B Cell Antigen Receptor." The objective of Dr. Neuberger's research is to understand the genetic control of antibody production and the regulation of the functioning of the immune system, using recombinant DNA technologies.

Simon Edward Victor Phillips, Ph.D.

Professor of Molecular Biophysics, Department of Biochemistry and Molecular Biology, University of Leeds

Dr. Phillips received his Ph.D. in the field of chemistry from University College London, in 1974, after which he pursued postdoctoral research training in chemical crystallography at the University of British Columbia, Canada, in the Department of Chemistry. He returned to the United Kingdom in 1976 to become Scientist at the Medical Research Council Laboratory of Molecular Biology in Cambridge. After an interval of research at the Institut Pasteur, Paris, he assumed an appointment as Lecturer in Biophysics at the University of Leeds in 1985, becoming Reader in 1989 and Professor in 1992. Dr. Phillips's honors include the Rapkine Lecture in 1990 at the Institut Pasteur and appointment to the editorial boards of *Nucleic Acids Research* and *Macromolecular Structures*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "Structural Studies of Protein-Nucleic Acid Complexes." The objective of Dr. Phillips's research is to understand sequence- and structure-specific recognition of nucleic acids by proteins.

James Cuthbert Smith, Ph.D.

Head, Laboratory of Developmental Biology, Medical Research Council National Institute for Medical Research, London

Dr. Smith received his Ph.D. in developmental biology from the University of London in 1979. He undertook postdoctoral research on growth factor action at the Sidney Farber Cancer Institute and Harvard Medical School, Massachusetts, and on amphibian development at the Imperial Cancer Research Fund, London. In 1984 he joined the scientific staff of the National Institute for Medical Research, being promoted to Senior Scientist in 1990 and to Laboratory Head in 1991. Dr. Smith's honors include the 1989 Scientific Medal of the Zoological Society of London and the 1991 Otto Mangold Prize of the German Society for Developmental Biology. He was elected to membership in the European Molecular Biology Organization in 1992, serves as a member of the editorial boards of *Cell*, *Cell Growth and Differentiation*, *Current Biology*, *Development*, and *Trends in Genetics*, and is co-chair of the 1993 Developmental Biology Gordon Conference. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Gradients and Thresholds in the Establishment of the Vertebrate Body Plan." The objective of Dr. Smith's research is to understand how graded distribution of regulatory molecules arises in early embryos, how these gradients result in differences in gene expression, and how such responses are modified by additional regulatory factors.

Alain Robert Townsend, M.B.B.S., Ph.D.

Professor, Department of Clinical Medicine, Institute of Molecular Medicine, University of Oxford

Dr. Townsend received his M.B.B.S. in 1977 from St. Mary's Hospital, London, and a Ph.D. in 1984 from the National Institute for Medical Research, also in London, in the field of immunology. He pursued postdoctoral research training at the Institute of Molecular Medicine in Oxford and was appointed New Blood Lecturer in Immunology in 1985 as well as Fellow of Linnacre College, Oxford. In 1992 he was appointed Professor at the Institute of Molecular Medicine. His postdoctoral training included the Todd-Bird Junior Research Fellowship in Medicine at New College, Oxford. In 1979 he became a Member of the Royal College of Physicians. Dr. Townsend was the 1989 recipient of the William B. Coley Award and Medal from the Cancer Research Institute, and the 1992 recipient of the Louis Jeantet Prize for Medicine. In that year, he was elected to the Royal Society (London). Dr. Townsend is an editor of the *Journal of Experimental Medicine*. The title of the research program to be supported under the Howard Hughes Medical Institute award is "The Biochemistry of Endogenous Antigen Presentation." Dr. Townsend's research seeks understanding of the molecular basis for the recognition of viruses by specific cells of the immune system and how tissue type influences human diseases, especially viral infections.

Richard Henry Treisman, Ph.D.

Principal Scientist, Imperial Cancer Research Fund, London

Dr. Treisman undertook his graduate research at the ICRF and received his Ph.D. from the University of London in 1981. He pursued postdoctoral research training in molecular genetics at Harvard University, Massachusetts, with the support of an ICRF Traveling Fellowship and a Special Fellowship from the Leukemia Society of America. In 1984 he joined the scientific staff of the MRC Laboratory of Molecular Biology, Cambridge, and moved to his current position at the ICRF in 1988. Dr. Treisman was elected to membership in the European Molecular Biology Organization in 1987. The research program to be supported by the Howard Hughes Medical Institute grant is titled "Transcription Factors in Growth Factor Action." The goal of Dr. Treisman's research is to understand the molecular basis of the regulation of gene transcription by extracellular signals.

Veronica van Heyningen, D.Phil.

Senior Scientist, Special Appointment Grade, Molecular Genetics Section, Medical Research Council Human Genetics Unit, Western General Hospital, Edinburgh; Honorary Fellow, Department of Biochemistry, University of Edinburgh

Dr. van Heyningen received her D.Phil. in 1973 in the field of genetics from the University of Oxford. Subsequently she was a Beit Memorial Fellow at the Genetics Laboratory, University of Oxford, and in the MRC Mammalian Genome Unit at Edinburgh, where she pursued her interest in genetic mapping and control of gene expression. Dr. van Heyningen was appointed to the staff of the MRC Human Genetics Unit in 1977, becoming Senior Scientist in 1986 and receiving a Special Appointment Grade in 1991. Her honors include designation as Co-Chair of the Chromosome-11 Committee for the International Human Gene Mapping Workshops in 1990 and Senior Genome Database Editor for Chromosome-11 in 1992. She also serves on the editorial boards of *Cytogenetics and Cell Genetics* and *British Journal of Cancer*. The Howard Hughes Medical Institute grant will support her research program on "Molecular, Genetic, and Functional Studies on *PAX6* and Other Aniridia Associated Genes in the WAGR Region." Dr. van Heyningen's work focuses on the role of the *PAX6* gene in development, how its expression is controlled, and the relationship of expressed traits such as aniridia (the absence of an iris) to the molecular nature of the mutation.

Australia

David Douglas Lawrence Bowtell, Ph.D.

Wellcome Trust Senior Research Fellow, Howard Florey Institute of Experimental Physiology and Medicine, University of Melbourne

Dr. Bowtell received his B.V.Sc. in 1981 and his Ph.D. in 1985 in the field of molecular parasitology, from the University of Melbourne. He was then a National Biotechnology Research Fellow at the Walter and Eliza Hall Institute, Parkville, conducting research in molecular genetics. In 1987 he moved to the University of California, Berkeley, as a C.J. Martin Fellow, to undertake postdoctoral research in developmental biology. He moved to the Howard Florey Institute in 1990 and assumed his present position there in 1992. The research program that will be supported by the Howard Hughes Medical Institute award is titled "Control of Cellular Differentiation in Mammalian Development." Dr. Bowtell's research focuses on the control of differentiation and pattern formation in the developing mouse retina and on pathways of intracellular signaling and development.

Suzanne Cory, Ph.D.

Senior Principal Research Fellow and Joint Unit Head, Molecular Biology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville

Dr. Cory received her Ph.D. in 1968 in molecular biology from the University of Cambridge. She then undertook postdoctoral research training at the University of Geneva, Switzerland, as a Rothmans Fellow at the Institute of Molecular Biology. She moved to the Walter and Eliza Hall Institute of Medical Research in 1972 and became Senior Principal Research Fellow and Joint Unit Head in 1988. Her honors include a Queen Elizabeth II Fellowship, a Roche Fellowship, the 1982 David Syme Prize, and election to the Australian Academy of Science in 1986 and the Royal Society in 1992. She also serves on the editorial boards of *Oncogene Research*, *International Immunology*, and *Cell Growth and Differentiation*. The research to be supported by the grant from the Howard Hughes Medical Institute is titled "Genetic Control of Hematopoietic Differentiation." Dr. Cory is studying the genetic mechanisms that control growth and differentiation in early development, maturation, and programmed cell death of blood cells.

Alan Frederick Cowman, Ph.D.

Wellcome Australian Senior Research Fellow, Immunoparasitology Unit, The Walter and Eliza Hall Institute of Medical Research, Parkville

Dr. Cowman received his Ph.D. in parasitology from the University of Melbourne in 1983. As a C. J. Martin Fellow, he pursued postdoctoral research training in molecular genetics at the University of California, Berkeley, in the Department of Biochemistry. In 1986 he joined the staff of the Walter and Eliza Hall Institute of Medical Research, as a Senior Research Officer, becoming Wellcome Australian Senior Research Fellow in 1988. Dr. Cowman is the recipient of the 1990 Burnet Prize and the 1992 Glaxo Award for Advanced Research in Infectious Diseases. The research to be supported by the Howard Hughes Medical Institute grant is titled "Molecular Mechanism of Drug Resistance in Malaria." Dr. Cowman's research will focus on the genetic basis for resistance to chemotherapeutic agents used against *Plasmodium falciparum*, the causative agent of the most severe form of human malaria.

David James Kemp, Ph.D.

Deputy Director, Menzies School of Health Research, Casuarina

In 1973 Dr. Kemp received his Ph.D. in biochemistry from the University of Adelaide, where he subsequently undertook postdoctoral training. He became a Research Scientist in the Division of Plant Industry at CSIRO, Canberra, in 1975; an Eleanor Roosevelt Fellow in the Department of Biochemistry at Stanford University, California, in 1976; and an American Cancer Society Senior Fellow, also at Stanford University, in 1977. The following year, Dr. Kemp joined the staff of The Walter and Eliza Hall Institute of Medical Research, Parkville, becoming Senior Principal Research Fellow and Head of the Immunoparasitology Unit in 1990. He was appointed Deputy Director of the Menzies School of Health Research in 1992. Dr. Kemp's honors include the 1981 Boehringer Medal of the Australian Biochemical Society, the 1985 Wellcome Lecture of the British Society for Parasitology, and the Wellcome Prize for Diagnostics in 1992. He also serves on the editorial boards of *DNA*, *Molecular and Biochemical Parasitology*, *Technique: A Journal of Methods in Cell and Molecular Biology*, and *PCR Methods and Applications*. The title of the research program to be supported by the Howard Hughes Medical Institute award is "Chromosome Deletions in Relation to Cytoadherence and Gametocytogenesis in *Plasmodium falciparum*." The aim of Dr. Kemp's research is to understand the molecular genetic factors that are central to host-parasite interactions, including cytoadherence and antigenic variation, for example, and may lead to new therapeutic approaches.

Grant Robert Sutherland, Ph.D., D.Sc.

Director, Department of Cytogenetics and Molecular Genetics, Adelaide Children's Hospital; Affiliate Professor, Department of Pediatrics, University of Adelaide Medical School; Honorary Consultant Geneticist, Queen Victoria Hospital, Adelaide

Dr. Sutherland received his Ph.D. in the field of cytogenetics from the University of Edinburgh in 1974. He also received a D.Sc. in human genetics from the University in 1984. Dr. Sutherland has been at the Adelaide Children's Hospital since 1975. His honors include election as President of the Human Genetics Society of Australia and as a council member of the Human Genome Organisation. He was a Fulbright Senior Scholar at the Southwest Biomedical Research Institute, Arizona, in 1983. Dr. Sutherland has served as Co-Chair of the Chromosome 16 Committee for the Human Genome Mapping Workshops and is on the editorial boards of several journals, including *Clinical Genetics*, *Journal of Medical Genetics*, *Mammalian Genome*, and *Human Molecular Genetics*. The research that will be supported under the grant from the Howard Hughes Medical Institute is titled "Studies of the Human Genome: Positional Cloning and Unstable DNA." The general goal of Dr. Sutherland's work is to contribute to the characterization of the human genome, concentrating on chromosome 16, fragile sites, and regions of special interest on other chromosomes.

New Zealand

Edward Neill Baker, Ph.D.

Professor of Biochemistry, Department of Chemistry and Biochemistry, Massey University, Palmerston North

Dr. Baker received his Ph.D. in the field of chemistry from the University of Auckland in 1968. He then undertook postdoctoral research in the area of protein crystallography at the University of Oxford as a Royal Society (London) Postdoctoral Fellow. He was appointed to the faculty of Massey University as a Lecturer in 1971, becoming Professor in 1989. Dr. Baker's honors include a Fulbright Senior Research Fellowship in 1984 to undertake a visiting appointment at the University of Oregon Institute of Molecular Biology and the 1983 ICI and 1985 Pharmacia Prizes for research in biochemistry. He was elected a Fellow of the New Zealand Institute of Chemistry and of the Royal Society of New Zealand in 1988. The research that will be supported under the Howard Hughes Medical Institute award is titled "Structural and Functional Analysis of Binding Proteins and Hydrolases." The broad objective of Dr. Baker's research is to analyze the relationships between the structure and function of binding and transport proteins, through x-ray crystallographic analyses complemented by site-directed mutagenesis.

Warren Perry Tate, Ph.D.

Professor of Biochemistry, University of Otago, Dunedin

Dr. Tate received his Ph.D. in biochemistry from the University of Otago in 1972. He then pursued postdoctoral research training in molecular genetics at Baylor College of Medicine, Texas, as an Arthritis Foundation Fellow. He became a Lecturer at the University of Otago in 1975 and assumed his present appointment as Professor in 1989. Dr. Tate's honors include the 1985 Pharmacia Research Prize, an Alexander von Humboldt Fellowship, under which he was a visiting scientist at the Max Planck Institute for Molecular Genetics, Berlin, and election to the Fellowship of the New Zealand Institute of Chemistry in 1986 and of the Royal Society of New Zealand in 1990. The title of the research program to be supported under the Howard Hughes Medical Institute grant is "Translational Stop Signals and Cellular Regulation." The objective of Dr. Tate's research is to explore mechanisms that may influence the termination of protein synthesis and to explore their possible importance in viral infectivity.

Program Assessment

Assessment within the grants program has two principal objectives: to document and measure key outcomes of the Institute's various grants initiatives, and to assist the development of new initiatives through studies of national trends in areas such as science education, the national research enterprise, and public and private support for science.

The Institute's assessment program has focused initially on outcomes for the grants programs in graduate and undergraduate science education, largely through analysis of annual progress reports submitted by individual fellows and institutional grant recipients. (See those chapters for data from these reports.)

In addition, several studies of national trends and conditions relevant to grants program planning are under way or have been completed. In conjunction with these internal activities, the Institute is working with several federal agencies and private organizations to draw on existing national databases and to develop new ones. These will be used for long-term monitoring of the careers of Institute-supported fellows, undergraduate science education productivity, and the supply of medically trained and other biological researchers. Program assessment activities are organized generally around the principal areas of the grants program.

Overview

Graduate Education in the Biological Sciences

In the graduate area, the Institute monitors the progress of its predoctoral, medical student, and postdoctoral fellows through information provided in their annual progress reports. As students proceed through their fellowship years and beyond, the Institute will continue to track their training and subsequent professional activities by monitoring advanced degrees and additional research training received, academic appointments, indicators of research involvement and productivity, and other career outcomes. National longitudinal databases will provide information on progress of the Institute's fellows as well as normative data on relevant national cohorts for comparison purposes.

Medical Student Fellows. An extensive tracking system for participants in the Research Training Fellowships for Medical Students program and those in the Howard Hughes Medical Institute/National Institutes of Health Research Scholars program is already well developed with support of a five-year grant to the Association of American Medical Colleges. The grant enables the AAMC to use a variety of national databases to track the educational progress and long-term careers of the Institute's fellows and scholars, as well as those of a number of national cohorts of other

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M.D. and M.D./Ph.D. graduates. The goal of the tracking is analysis of the impact of various types of research experiences on subsequent career involvement in research. This tracking project and preliminary results from it were summarized in *Grants for Science Education, 1991–1992.*

Data are presented later in this chapter on the numbers of 1991–1992 medical students and 1992 M.D. graduates known to have been enrolled in M.D./Ph.D. dual-degree programs, including those known to have received support through the NIH Medical Scientist Training Program. More extensive reporting of results from the tracking project is planned for presentation in *Grants for Science Education, 1993–1994.*

Predoctoral Fellows. A parallel effort to track the progress of the Institute's predoctoral fellows is currently under development and will be initiated during 1992–1993. This effort will be based primarily on responses provided by fellows to a periodic survey concerning educational and career outcomes and plans for the future. National databases may be used as secondary data sources in this assessment effort.

Undergraduate Science Education

Program assessment in the undergraduate area has focused on institutions receiving grant support through the Institute's undergraduate grant program, using both annual progress reports and several national databases. Each college or university receiving an Institute award submits an annual report detailing its Institute-supported activities. These reports provide data on student development in the sciences, covering topics such as involvement in research and acceptance into graduate or medical school. The Institute is particularly interested in monitoring the participation of women and students from minority groups underrepresented in the sciences.

The annual progress reports also cover science faculty, curriculum, and laboratory development, and a variety of outreach programs. (See the chapter on undergraduate science education for a summary of these data.)

Recent Baccalaureate Origins. Supplementing the annual reports, information derived from various national databases provides detailed analyses of institutional productivity in science education at the undergraduate level. The process of selecting the colleges and universities to compete in each round of the Institute's Undergraduate Biological Sciences Education program has been based on these extensive records of recent science education productivity at the undergraduate level. Relevant productivity data include the numbers and proportions of recent baccalaureate graduates who went on to earn doctorates in sciences and mathematics and to matriculate in U.S. medical schools.

The productivity data cover nearly all colleges and universities offering the bachelor's degree. They represent science doctorates and medical school matriculants over the most recent 10-year period for which the doctorate data are available (1979–1988). Results from this assessment effort are summarized later in this chapter (pages 96-103).

Precollege and Public Science Education

Because the Institute has only recently created grant initiatives under the precollege and public science education program, the associated program assessment activities are in the early stages of development. Nevertheless, it is intended that each major grant program supporting precollege and public science education will have an assessment component. Planning and development of assessments for the precollege program will take into account experience gained from assessment programs in the graduate and undergraduate science education areas.

Local Precollege Initiatives. The local precollege education initiatives are profiled in the chapter on precollege and public science education. Assessment programs are being developed with the Montgomery County Public Schools and the National Institutes of Health. The Office of Grants and Special Programs is supporting the Montgomery County Public Schools Office of Educational Accountability project to collect, analyze, and report key data on participants in the local grants program initiatives involving the Montgomery County Public Schools and NIH. Selected educational and career outcomes for both student and teacher participants will be tracked primarily through annual surveys and selected interviews for at least five years following participation. Some attitudinal surveying also may be done before and after participation in the program (Figure 55).

For high school student participants, the tracking surveys will gather data primarily on long-term outcomes, such as graduation from high school, college matriculation, attainment of a baccalaureate degree, undergraduate major, graduate-level training in the sciences, and enrollment in medical school. For teachers, the surveys will assess areas such as knowledge of science, attitudes about science, and certain behavioral outcomes, including approaches to teaching biological science before and after participation in the programs.

Results from this tracking program will be reported on an annual and cumulative-to-date basis for student and teacher participants in each of the three local grant programs. These data will be studied and reported in aggregate with participants from each year of the programs forming separate cohorts for analysis.

Finally, a formative evaluation of the student and teacher intern program, which provides research op-

Figure 55

Program Assessment Database for Local Precollege Initiatives

Information and Outcomes to Be Monitored

Student Participants

- Science/math courses taken and grades earned in high school
- Post-participation science activities (e.g., science fairs, research publications, summer science research)
- Post-secondary education plans at high school graduation
- Post-secondary educational institutions attended
- Undergraduate major
- Undergraduate research experiences
- Post-secondary degrees
- Demographic variables (e.g., gender, ethnic background)

Teacher Participants

- Impact of participation on curriculum taught, laboratories developed and conducted, teaching methods, and further research conducted
- Courses taught during and after program participation
- Impact on department and school through interaction with other teachers
- Subsequent professional development activities (e.g., change in school, new teaching responsibilities, change in occupation, move to administration)
- Demogaphic variables (e.g., gender, ethnic background)

portunities for Montgomery County students and teachers at NIH, is being conducted during 1992–1993. The evaluation probes participants' short-term experiences, issues related to the general operation of the program, and early program outcomes.

The experience and results gained from assessment activities related to the local grants initiatives should provide useful models for assessment of other precollege science education activities of the grants program.

Future Efforts, Including Studies in Philanthropic Support for Science

Additional assessment activities will address broad national issues, particularly as they relate to the development of new grants initiatives and to assessment of existing programs. An example of such work is the ongoing effort to monitor recent support for science education and research by foundations and voluntary health associations. In 1990 the Institute published a monograph on this subject entitled *Support for Science Education and Research by Foundations and Voluntary Health Associations*. Results from this research also were summarized in *Grants for Science Education, 1990–1991*. The 1990 research was based primarily on data collected at the individual grant level that were submitted to the U.S. Internal Revenue Service through the 990-PF forms. Supplemental data were taken from annual reports and grant lists of foundations and other relevant organizations. These data primarily represented grants made in 1986.

The current effort is intended to update the 1986 information. The data for 1991 may reveal funding trends since 1986 as well as document very recent levels and patterns of private support for science education and research. The Foundation Center, a resource for information on foundations, identified an initial study set of 850 foundations with programs that might include support for scientific research and science education. These foundations were queried by the Institute concerning areas of grant support during 1991, and on the basis of those queries 401 were determined to have provided support for research and/or education programs in the natural sciences and mathematics.

For the voluntary health associations, the initial study set included the 39 current members of the National Health Council. Each of these organizations was screened as the foundations had been screened. Based on grant support provided for science education and reported in 1991, 27 voluntary health associations were included in this study. In the summer of 1992, the 401 foundations and 27 voluntary health associations that had reported recent grant activity in the areas of interest for this study were mailed a questionnaire. Subsequent interviews by telephone elicited data on 1991 grant activities supporting science education and research.

This initial phase will provide aggregate data at the level of the grantmaking agencies concerning recent support for scientific research and science education by foundations and voluntary health associations. A second phase of the study may be undertaken to collect and analyze data at the level of individual grants. The latter approach was taken in the study published on data for 1986. Results of the current study will be included in *Grants for Science Education, 1993–1994.*

Figure 56

Students Reported to Have Been Enrolled in M.D./Ph.D. Dual-Degree Programs[1]

Continuing Students and M.D. Graduates, 1991-92

	Continuing Students		M.D. Graduates, 1992		Total Enrollment	
Dual-Degree Program[2]	N	%	N	%	N	%
With MSTP Support	854	46	141	44	995	46
With Other or No Support	983	54	183	56	1,166	54
Totals[3]	1,837	100%	324	100%	2,161	100%

[1] *Data represent M.D. students reported by their medical schools to have been enrolled in M.D./Ph.D. programs.*

[2] *"With MSTP Support" indicates students listed by their medical school, in reports to the National Institutes of Health, as supported through the NIH Medical Scientist Training Program award to that school. Such support could have been for any year(s) between 1978 and 1991 (inclusive).*

"With Other or No Support" indicates students listed by their medical school, in reports to the Association of American Medical Colleges, as enrolled in an M.D./Ph.D. program (and not subsequently reported as withdrawn from the program), but who are not on the NIH rosters of those having received MSTP support.

[3] *These data do not represent the M.D./Ph.D. population per se; only students reported to have been enrolled in such dual-degree programs. Some of the graduates will not complete the Ph.D. until one or more years following the M.D. Other students and graduates may permanently have dropped the Ph.D. component of their studies. Also, there may be students enrolled in M.D./Ph.D. programs not reflected in these data because they are not reported to be in dual-degree programs. Finally, many M.D.'s also holding the Ph.D. earn the doctorate before entering medical school, and so are never enrolled in dual-degree programs.*

Graduate Education: The Annual Pool of Students in M.D./Ph.D. Programs

Through the Institute's grant to the Association of American Medical Colleges, annual data are gathered on the size and characteristics of the national pool of M.D./Ph.D. students and graduates. Informal surveys have estimated the number of medical students enrolled in M.D./Ph.D. programs in selected years. These studies have suggested that about one-half of all such dual-degree program students receive support through the NIH Medical Scientist Training Program (MSTP), the principal single source of funding for M.D./Ph.D. candidates. However, comprehensive data have not been systematically available on either enrollments or graduates of dual-degree programs.

In *Grants for Science Education, 1990–1991* and *1991–1992*, data were presented on medical students who were reported to be enrolled in M.D./Ph.D. programs during the 1989–1990 and 1990–1991 academic years, respectively. These preliminary findings were based, in part, on reporting by medical schools to the AAMC concerning students enrolled in dual-degree programs. However, this reporting was known to be incomplete. Under the Institute's grant, the AAMC continued an ongoing effort in 1992 to ensure that the reporting is complete, accurate, and timely. The AAMC has also continued to work with NIH to improve the accuracy, completeness, and timeliness of information on students receiving MSTP support. As a result, the data are significantly improved on medical students enrolled in, and graduating from, dual-degree programs during the 1991–1992 academic year and, to some extent, in earlier years as well.

Information currently available from the AAMC and NIH indicates that a total of 2,161 medical students were enrolled in M.D./Ph.D. programs during the 1991–1992 academic year, of whom 995, or 46 percent, are known to have received MSTP support at some point while in medical school (Figure 56). In any one year, approximately 750 full-time equivalent students receive MSTP support. The reported number who received MSTP support, particularly among those continuing as medical students, is expected to increase somewhat, once complete data on students supported for the first time during 1991–1992 become available from NIH (in about one year). However, this information is not expected to increase the estimated proportion of M.D./Ph.D. students receiving MSTP support significantly above the level found here.

Of the 2,161 medical students reported in M.D./Ph.D. programs during the 1991–1992 academic year, 324 were awarded the M.D. degree in 1992. Of these M.D. graduates, at least 141, or 44 percent, received MSTP support at some time during their enrollment in medical school.

In addition to information on the 1992 M.D. graduates, data have been assembled for the graduating classes of 1988 through 1991 on the annual number of M.D. graduates reported to have been enrolled in M.D./Ph.D. programs (Figure 57). The historical data identify between about 200 and 325 such students awarded the M.D. each year, with slightly less than one-half (in the most recent three years) known to have received MSTP support at some point during their enrollment in medical school.

The apparent steady increase since 1988 in the numbers reported to have graduated from dual-degree programs, particularly among those not supported through the MSTP, may represent real growth in the annual number of M.D. graduates emerging from M.D./Ph.D. programs. However, this apparent growth may also be an artifact, at least in part, of improved reporting by the medical schools, as discussed previously. Over the next several years, data on enrollment in

M.D./Ph.D. programs collected through this project should provide a consistent and accurate picture of the annual pool of such dual-degree students and graduates.

It should be noted that these data on enrollments and M.D. graduates do not represent the M.D./Ph.D. pool per se. Rather, they represent M.D. students and graduates identified as having been enrolled in M.D./Ph.D. programs, based on receipt of MSTP support and/or on enrollment information provided by medical schools. While receipt of the M.D. is confirmed for the graduates, receipt of the Ph.D. is not. Some of the graduates will not formally be awarded the Ph.D. until one or more years after the M.D. Also, some of the students and graduates may have permanently dropped the Ph.D. component of their studies. However, most of the recent M.D. graduates known to have been enrolled in M.D./Ph.D. programs have earned doctorates. (See *Grants for Science Education, 1991–1992*, pages 71–73.)

In addition, there may be other medical students enrolled in, and graduating from, M.D./Ph.D. programs who are not reported to the AAMC by the medical schools. Finally, other analyses from this project indicate that many M.D./Ph.D.'s earn the doctorate well before the M.D. and thus never enter a dual-degree program. (See *Grants for Science Education, 1991–1992*, pages 73–75.)

Figure 57

Recent M.D. Graduates Identified as Having Been Enrolled in M.D./Ph.D. Programs

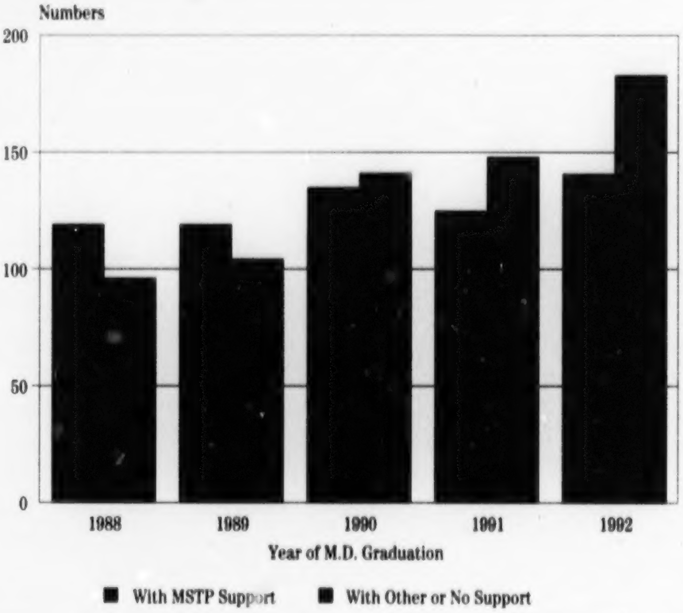


Figure 58

Assessment Criteria and Data Sources

Data on 1,413 colleges and universities from nine relevant Carnegie classifications were analyzed to identify institutions for participation in the Undergraduate Biological Sciences Education Program. Institutions were assessed on the basis of the percentage[1] and absolute numbers of graduates from each institution who have:

- **Matriculated in Medical School (1979–1988),[2]**
- **Earned a Doctorate in Biology (1979–1988),[3] or**
- **Earned a Doctorate in Chemistry, Physics, or Mathematics (1979–1988).[3]**

[1] *Computed using total number of baccalaureate degrees conferred. Data Source: Department of Education*

[2] *Data Source: Association of American Medical Colleges*

[3] *Data Source: National Resource Council/National Academy of Sciences.*

Undergraduate Education: Baccalaureate Origins of Recent Matriculants to Medical School and Recent Recipients of Doctoral Degrees in Selected Sciences and Mathematics (1979–1988)

As noted in the chapter on undergraduate science education, institutions have been invited to compete for support through the Institute's undergraduate program on the basis of recent measures of science education productivity at the baccalaureate level. Specifically, these invitations have been based on the absolute number and proportion of baccalaureate graduates having gone on to matriculate in medical school, the number and proportion having earned doctoral degrees in the biological sciences, and the number and proportion having earned doctoral degrees in chemistry, mathematics, physics, or astronomy. The data used represented medical school matriculation and doctoral degrees earned between 1979 and 1988, the most recent ten-year period for which these data were available when the analyses were conducted (Figure 58).

As a result of this work for the undergraduate science education program, the Institute has assembled an extensive data set on the baccalaureate origins of recent medical school matriculants and recipients of recent doctoral degrees in selected scientific and mathematical fields. Analyses of these data update or expand similar studies of baccalaureate origins (e.g., Fuller, 1986) by including data based on a recent 10-year period, the undergraduate origins of medical school matriculants, and both the absolute numbers and the proportions of recent baccalaureate graduates having gone on to these scientific and medical outcomes, and detailed data on each of over 1,400 U.S. colleges and universities.

Basic Methodology

The institutions included in this study were all those classified by the Carnegie Foundation for the Advancement of Teaching (1987) as:

	Number
Research Universities I and II	104
Doctorate-Granting Universities I and II	109
Comprehensive Colleges and Universities I and II	595
Liberal Arts Colleges I and II	574
Schools of Engineering and Technology	31

These categories included a total of 1,413 institutions representing most U.S. universities and four-year colleges awarding the baccalaureate degrees of the nation's scientists and physicians (Figure 59). For example, these institutions awarded baccalaureate degrees to 32,252 (85 percent) of the 38,318 recipients of earned doctoral degrees in the biological sciences awarded between

Figure 59

Carnegie Classifications

The Carnegie Foundation for the Advancement of Teaching classifies colleges and universities on the basis of such factors as percentage of baccalaureate degrees awarded in the arts and sciences or professional fields, enrollment, and degree of specialization in technical disciplines. The Institute's evaluations of institutions for participation in the undergraduate competitions were based on the 1987 Carnegie classifications and included the following classifications and categorical definitions for public and private institutions:

Research Universities I and II

These institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. Research I universities receive annually at least $33.5 million in federal support for research and development and award at least 50 Ph.D. degrees each year.

Research II universities receive annually between $12.5 million and $33.5 million in federal support for research and development and award at least 50 Ph.D. degrees each year.

Doctorate-Granting Universities I and II

In addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctorate. Doctorate-Granting I universities award at least 40 Ph.D. degrees annually in five or more academic disciplines. Doctorate-Granting II universities award annually 20 or more Ph.D. degrees in at least one discipline or 10 or more Ph.D. degrees in three or more disciplines.

Comprehensive Colleges and Universities I and II

These institutions offer baccalaureate programs, and many also offer graduate education through the master's degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines such as engineering or business administration. Comprehensive I institutions enroll at least 2,500 students. Comprehensive II institutions enroll between 1,500 and 2,500 students.

Liberal Arts Colleges I and II

These institutions are primarily undergraduate colleges that award more than half of their baccalaureate degrees in arts and sciences fields. The Liberal Arts II category also includes a group of colleges that award less than half their degrees in liberal arts fields, but with fewer than 1,500 students are too small to be considered comprehensive.

Schools of Engineering and Technology

These institutions award at least a bachelor's degree in programs limited almost exclusively to technical fields of study.

1979 and 1988 by institutions of higher education in the United States and its territories. The 1,413 institutions in this study accounted for fully 95 percent of the baccalaureate degrees of U.S. citizens and permanent residents who earned doctoral degrees in these fields during the period of study (31,578 of 33,231).

All data for these studies were derived from standard national sources. Information on the baccalaureate origins of recent doctoral degree recipients was taken from data tables published on this subject in 1989 by the National Research Council (NRC) based on the Doctorate Records File. The DRF is the national repository of information on all doctoral degrees awarded in the United States. It is maintained by the NRC chiefly for the National Science Foundation and the National Institutes of Health. The DRF is "a virtually complete database of 916,615 doctorates earned at U.S. universities between the years 1920 and 1988" (NRC, 1989).

Data on the undergraduate origins of recent matriculants to medical schools were provided by the Association of American Medical Colleges (AAMC) from the Student and Applicant Information Management Systems, an essentially complete database of all applicants and matriculants to U.S. (and many Canadian) allopathic medical schools. This database is developed and maintained through the AAMC's common application procedure whereby students wishing to pursue medical studies complete a single application form, which is mailed to the AAMC and distributed by the AAMC to the applicants' selected medical schools.

Analyses of the proportions of recent baccalaureate graduates who achieved these medical, scientific, and mathematical outcomes required information on total numbers of baccalaureate graduates. The data were derived from annual reports provided by the U.S. Department of Education National Center for Education Statistics on total baccalaureate degrees conferred. These data are submitted annually to the Department of Education by the educational institutions through the Higher Education General Information Survey "Earned Degrees Conferred" report and, more recently, the Integrated Post-Secondary Education Data Systems "Completions" survey. Data on total baccalaureate degrees conferred were assembled for each year from 1971 through 1988 for each of the 1,413 universities and colleges in the study.

The proportional analysis of recent doctoral degrees was performed by dividing each institution's number of baccalaureate graduates having earned doctoral degrees in each of the fields studied during the 10-year period of analysis (1979–1988) by the total number of baccalaureate degrees conferred during the 10-year period 1971–1980. This eight-year offset in the two periods of analysis approximately adjusts for the median 7.8 years between the baccalaureate degree and an earned doctoral degree in these fields (NRC, 1987).

The proportional analysis for recent matriculants to medical school also divided each institution's number of baccalaureate graduates who enrolled in medical school between 1979 and 1988 by a 10-year total number of baccalaureate graduates. However, this analysis did not involve an offset in these two study periods because the AAMC's records indicated a median time of less than one year between receipt of the baccalaureate degree and matriculation to medical school.

Basic Findings

Analyses of absolute and proportional data on the baccalaureate origins of recent medical school matriculants and doctoral degree recipients in the sciences and mathematics reveal several fundamental patterns:

- The number of colleges and universities that might be considered highly productive of future physicians and scientists, either in absolute numbers or as a proportion of baccalaureate graduates, is relatively small compared to the full study set of 1,413 such institutions.
- The institutions most productive in absolute numbers tend strongly, although not exclusively, to be the Research and Doctorate-Granting Universities, with slightly more than one-half being public institutions.

Figure 60

Institutions Ranked by Number of Baccalaureate Alumni Who Matriculated in Medical School (1979–1988)

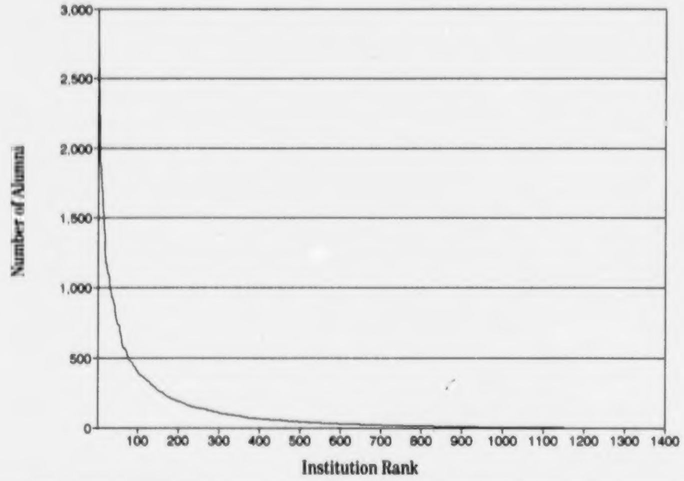


Figure 61

Institutions Ranked by Proportion of Baccalaureate Alumni (1971–1980) Who Matriculated in Medical School (1979–1988)

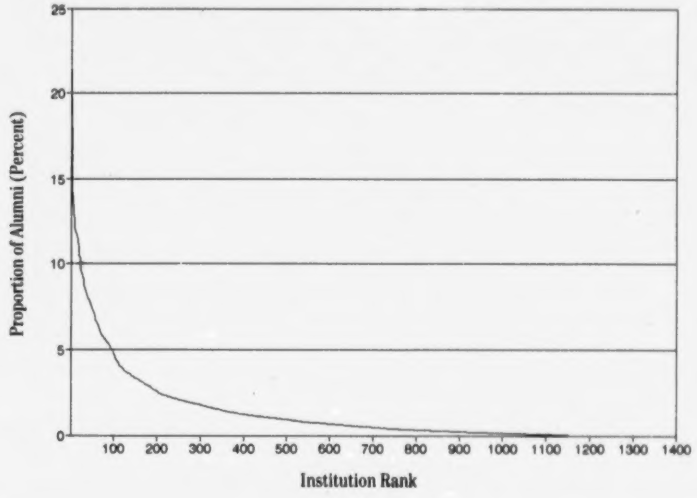


Figure 62

Institutions Ranked by Number of Baccalaureate Alumni Who Earned Doctoral Degrees in Biological Sciences (1979-1988)

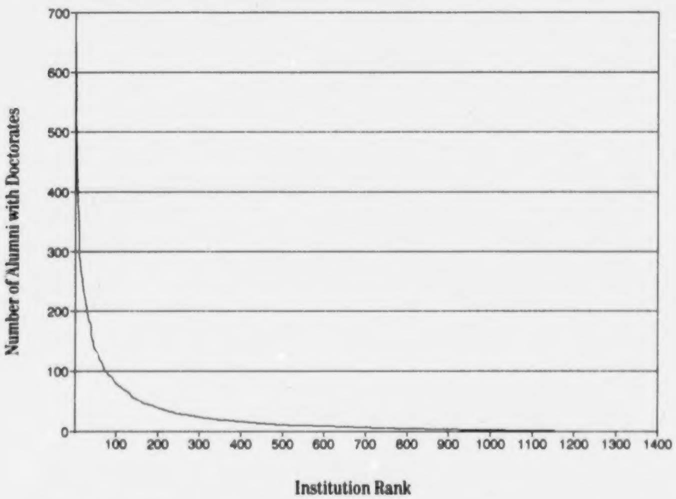
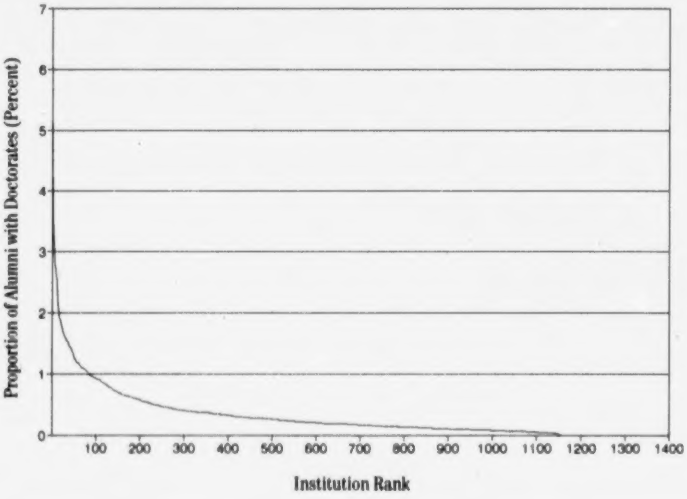


Figure 63

Institutions Ranked by Proportion of Baccalaureate Alumni (1971-1980) Who Earned Doctoral Degrees in Biological Sciences (1979-1988)



- The institutions most productive in proportional terms tend strongly, although not exclusively, to be private Liberal Arts College I institutions.
- Some variation in these patterns exists among the scientific and mathematical disciplines studied, and between the baccalaureate origins of the doctoral degree recipients and those of medical school matriculants, but these differences tend to be small.

For each of the 1,413 colleges and universities included in this study, Figures 60 and 61, respectively, plot the absolute numbers and proportions of recent baccalaureate graduates who matriculated in medical school. Figures 62 and 63 present parallel analyses concerning baccalaureate graduates earning recent doctoral degrees in the biological sciences. These data indicate that relatively few of the 1,413 institutions graduated either large numbers or high proportions of undergraduates who subsequently enrolled in medical school or earned doctoral degrees in these fields. Nearly identical patterns were found for the baccalaureate origins of doctoral degree recipients in the other scientific and mathematical disciplines studied.

These findings indicate that the baccalaureate degrees of a majority of future physicians, scientists, and mathematicians are awarded by relatively few of the nation's colleges and universities. Figure 64 presents the numbers of recent

Figure 64

Numbers and Percentages of All Recent Medical School Matriculants and Doctoral Degree Recipients in Selected Sciences and Mathematics with Undergraduate Origins from Three Institutional Groups

	Medical School Matriculants		Biological Sciences Ph.D.'s		Chemistry Ph.D.'s		Mathematics Ph.D.'s		Physics and Astronomy Ph.D.'s	
Institution Group	Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total	Number	% of Total
Top 100	89,615	58.1	17,907	55.5	5,960	44.5	2,575	59.3	5,086	68.2
Top 250	125,582	81.4	25,005	77.5	9,471	70.7	3,609	83.1	6,465	86.7
Top 500	145,547	94.4	29,522	91.5	12,185	91.0	4,343	100.0	7,293	97.8
All 1,413	154,249	100.0%	32,252	100.0%	13,393	100.0%	4,343	100.0%	7,457	100.0%

medical school matriculants and doctoral degree recipients in the sciences and mathematics whose undergraduate degrees were from the 100, 250, and 500 colleges and universities most productive (in absolute numbers) in each of these areas respectively. The table also presents the total number of recent medical school matriculants and relevant doctoral degree recipients with baccalaureate degrees from the 1,413 institutions studied.

In general, about 55–70 percent of all recent medical students and doctoral degree recipients in these fields received baccalaureate degrees from the respective 100 most productive institutions in these areas. (The percentage for chemistry was somewhat lower.) The top 250 institutions awarded the baccalaureate degrees for about 70–85 percent of these totals, and the top 500 were the baccalaureate origins of at

Figure 65

Carnegie Classifications of the 100 Most Productive Institutions in Number of Baccalaureate Alumni Who Matriculated in Medical School (1979-1988)

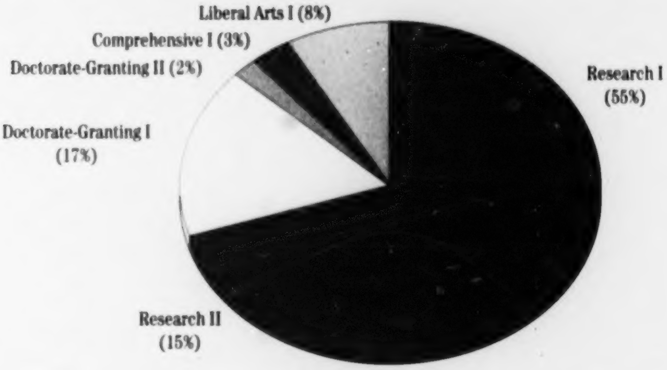
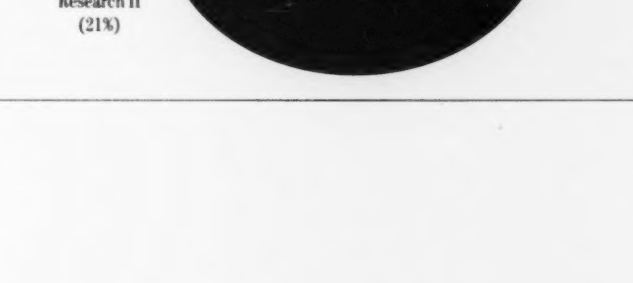


Figure 66

Carnegie Classifications of the 100 Most Productive Institutions in Number of Baccalaureate Alumni Who Earned Doctoral Degrees in Biological Sciences (1979-1988)



least 91 percent of all such medical students and doctoral degree recipients. The relatively few colleges and universities graduating large numbers and proportions of baccalaureate students who go on to become physicians, scientists, and mathematicians are thus of particular interest.

Figure 65 presents the Carnegie classifications of the 100 colleges and universities with the largest *numbers* of baccalaureate alumni recently matriculated in medical school. Figure 66 presents a parallel analysis for the 100 institutions with the largest *numbers* of undergraduate alumni having earned recent doctoral degrees in the biological sciences. In each case, over one-half (55 percent) of these institutions were Research Universities I. The Research and Doctorate-Granting Universities collectively represented approximately 90 percent of each of these two sets of top 100 colleges and universities. Similar patterns were found for each of the other scientific disciplines and mathematics.

Public institutions formed between 55 percent (medical school matriculants) and 59 percent (chemistry and mathematics) of these sets of the 100 most productive institutions, with only one exception. The exception was among the 100 with the largest numbers of baccalaureate alumni awarded recent doctoral degrees in the biological sciences, of which 68 percent were public institutions.

Figures 67 and 68 present the sets of colleges and universities with the highest *percentages* of baccalaureate alumni who matriculated in medical school or have been awarded doctoral degrees in the sciences or mathematics. The patterns are substantially different from those seen for absolute numbers. In terms of Carnegie classification, Liberal Arts Colleges I formed between 40 percent (physics and astronomy) and 62 percent (biological sciences) of the respective sets of 100 most proportionally productive institutions in each of the five areas studied. All Research and Doctorate-Granting Universities comprised between approximately 30 and 40 percent of these institutions, with Research Universities I forming between roughly 20 and 25 percent. Between 85 percent (physics and astronomy) and 93 percent (medical school matriculants) of the sets of 100 most proportionately productive colleges and universities were private institutions.

Tables providing detailed information about the 100 most productive institutions in absolute numbers and the 100 most productive in proportion of baccalaureate graduates for each of the five outcomes studied (i.e., medical school matriculants and doctoral degrees in the biological sciences, chemistry, mathematics, and physics/astronomy) will be published in a separate monograph on this study of baccalaureate origins.

Figure 67

Carnegie Classifications of the 100 Most Productive Institutions in Proportion of Baccalaureate Alumni (1971-1980) Who Matriculated in Medical School (1979-1988)

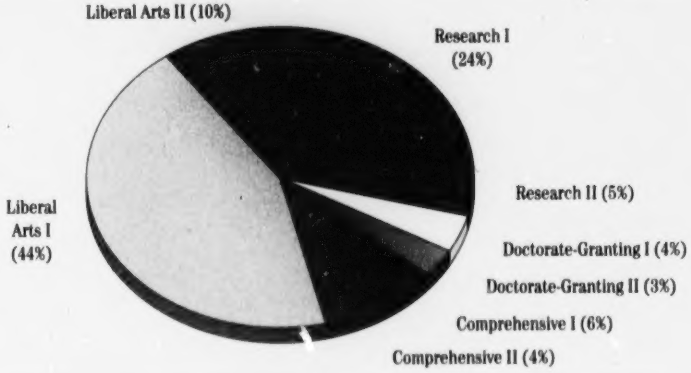
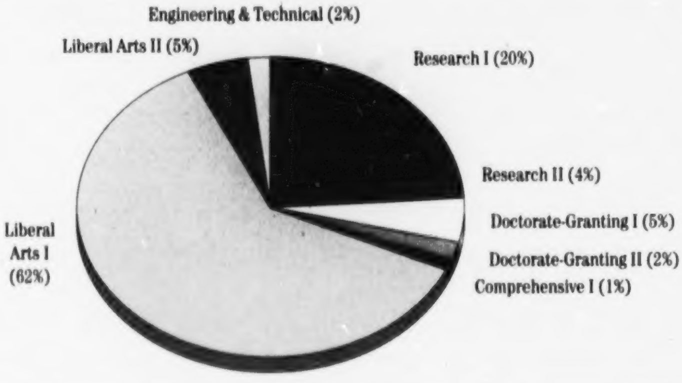


Figure 68

Carnegie Classifications of the 100 Most Productive Institutions in Proportion of Baccalaureate Alumni (1971-1980) Who Earned Doctoral Degrees in Biological Sciences (1979-1988)



Policies and Procedures for Grant Applications

Grants awarded by the Howard Hughes Medical Institute are administered by the Institute's Office of Grants and Special Programs. Grants are made under specific initiatives, each of which has individual objectives and guidelines.

Graduate fellowships and grants for undergraduate and precollege science education are awarded on the basis of applications or proposals reviewed by panels of scientists and educators in academia, government, and industry. The evaluations by these panels are then reviewed by an internal scientific committee that makes recommendations to the Institute's Trustees, who authorize funding. In addition, the Institute's Trustees and management annually review current grants program policies, initiatives, and possible directions for program development.

The grants program does not make awards for support of research in the United States, or for institutional training grants, nor does it award grants specifically to support conferences or the publication of conference proceedings. Policies and procedures for the program components in each area are described below.

Graduate Education in the Biological Sciences

Predoctoral Fellowships in Biological Sciences

These fellowships provide support for up to five years of full-time study toward the Ph.D. or Sc.D. degree in areas of the biological sciences. Awards are made to individual students, based on an international competition. Processing and review of the fellowship applications are managed by the Fellowship Office of the National Research Council/National Academy of Sciences.

The application deadline is early November each year, and awards are announced by early April. This fellowship program makes awards to individual students; it does not provide institutional training grants.

Research Training Fellowships for Medical Students

Fellowships awarded under this program enable medical students in the United States to undertake a year of full-time fundamental research. Awards are based on a national competition. The application deadline is early December each year, and awards are announced by early April. Awards are made to individual students; the program does not provide institutional training grants.

Postdoctoral Research Fellowships for Physicians

These fellowships provide support for three years of full-time research for physicians who have completed at least two years of postgraduate clinical training and no more than two years of postdoctoral research training by the start of the fellowship. Awards are based on an international competition. The

For Predoctoral Fellowships in Biological Sciences program announcements and applications, contact:

Hughes Predoctoral Fellowship Program
National Research Council
Fellowship Office
2101 Constitution Avenue
Washington, DC 20418
(202) 334-2872

For Research Training Fellowships for Medical Students program announcements and applications, contact:

Howard Hughes Medical Institute
Office of Grants and Special
Programs/MED
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8884
Fax: (301) 215-8888

For Postdoctoral Research Fellowships for Physicians program announcements and applications, contact:

Howard Hughes Medical Institute
Office of Grants and Special
Programs/POST
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8884
Fax: (301) 215-8888

application deadline is January 1 of each year, and awards are announced by the end of July. Awards are made to individual physicians; the program does not provide institutional training grants.

Research Resources

This program provides support to research and educational institutions in the United States that serve as national resource laboratories and teaching facilities, including those supplying unique biological stocks and materials. The Institute limits grants under this initiative to organizations whose activities not only serve the biomedical research community as a whole but also coincide directly with established Institute programs. All proposals in this area will be rigorously evaluated to ensure that these awards are limited to areas of specific Institute interest and are consonant with demonstrated need.

Undergraduate Biological Sciences Education Program

Awards under this grants program are intended to strengthen education and research in the biological sciences and related fields, such as chemistry, physics, and mathematics, at the undergraduate level in U.S. academic institutions. Applications are solicited by invitation only.

The institutions selected to compete in the undergraduate program are those with demonstrably outstanding recent records of preparing students for graduate and medical school and for careers in research, teaching, or the practice of medicine. Institutions are selected to participate in the competition on the basis of data available from the Association of American Medical Colleges, the National Research Council, and the U.S. Department of Education. (See the undergraduate science education chapter for more detailed information on institutional assessment.)

Among the objectives of the undergraduate science education program are to attract and retain science students, including women and students from minority groups underrepresented in the sciences, by supporting stimulating laboratory research experiences; to provide for the acquisition of modern equipment and laboratory renovations to strengthen the quality of undergraduate science education; and to help strengthen linkages among colleges and universities and elementary and secondary schools, junior and community colleges, and other two- and four-year institutions by providing opportunities in the sciences for teachers and students.

For the 1993 grants competition, the Institute has invited 185 public and private institutions classified by the Carnegie Foundation for the Advancement of Teaching as Comprehensive Colleges and Universities I and II, Liberal Arts Colleges I and II, and Schools of Engineering and Technology. These institutions were assessed for the 1993 competition on the basis of the most recent available data. In addition, a number of institutions were invited to participate on the basis of their records of graduating students from minority groups underrepresented in the sciences who have gone on to matriculate in medical school or to earn doctorates in biology, chemistry, physics, or mathematics from 1979–1988. (See page 34 of this report for a list of 1993 invited institutions.)

Precollege and Public Science Education

Through this grants program, the Institute explores avenues of support for precollege and public science education. Initiatives are designed to address the level of scientific knowledge and interest of both school-age and adult populations.

In 1987 the Institute awarded a grant to the Board on Biology, Commission on Life Sciences, National Research Council, to support a comprehensive study of biology education from elementary through secondary school. In September 1990 the NRC published a report, ***Fulfilling the Promise–Biology Education in the Nation's Schools***, based on the study supported by the Institute.

A number of factors are carefully considered in the development of grants initiatives in precollege and public science education. Among these are the major findings and recommendations of the NRC report, new national science education initiatives, and results of the precollege-oriented outreach activities currently supported under the Institute's undergraduate science education program. With the exception of the Precollege Science Education Initiative for Science Museums described below, no applications will be entertained until further program development is undertaken.

Precollege Science Education Initiative for Science Museums

The 1992 awards support science education programs for children and youth, their teachers and families, and community organizations through children's museums, general science museums, natural history museums, and science and technology centers.

For the 1993 competition, 170 institutions were invited, including for the first time aquaria, botanical gardens, arboreta, and zoos. The competitors were selected by the Institute after consultation with numerous experts in the field. Reviewers took into consideration such factors as experience in delivering high-quality science education programs to children, youth, teachers, and families, as well as existing relationships with schools or other educational organizations. Further, the Institute examined the results of the 1992 grants competition for children's museums and science museums to identify institutions that did not receive awards but had submitted proposals that were highly rated by the external review panel. The application deadline for the second invitational competition was January 15, 1993, and awards will be announced in August 1993.

Health Sciences Policy

In considering future grants program development, the Institute plans to explore possible initiatives in the general areas of health sciences policy and bioethics. A grant to the Institute of Medicine/National Academy of Sciences is supporting studies and activities designed to foster fundamental research, facilitate the transfer of knowledge from laboratory to clinic, and provide for early assessment of the impact that advances in science will have on society. In addition, among the activities supported under the Institute's $1 million grant to the Human Genome Organisation is an exploration of the potential scientific, social, legal, ethical, and commercial impact of human genome research on society.

The studies and reports that result from the grants to the Institute of Medicine and the Human Genome Organisation will be used to help guide the Institute in developing possible future grants initiatives in the areas of health sciences policy and bioethics. The Institute will not consider applications for projects in these areas at this time.

International Program

International Research Scholars Program

In recognition of the important contributions of scientists abroad to advances in biomedical science, the Institute has launched a limited International Research Scholars Program. Because this program is small and experimental in nature, it is limited to specific selected countries. The first awards, announced in June 1991, were made to support the research of scientists at institutions in Canada and Mexico. The second competition was for the United Kingdom, Australia, and New Zealand, and awards were announced in December 1992.

Each grant is for a term of five years and is intended to support research expenses, with considerable flexibility in the allocation of funds within each grant. The designated scholars are promising scientists who have already made significant contributions to fundamental biomedical research and who are still developing. The awards are not intended for those in the later phases of distinguished research careers. Scholars must hold appropriate full-time academic or research appointments and may not be citizens or permanent residents of the United States.

The Institute's management, its Medical Advisory and Scientific Review Boards, its investigators, selected outside advisers, and officials of leading biomedical organizations in the eligible countries are invited to submit nominations of candidates.

A large group of biomedical scientists with appropriate expertise evaluates eligible nominees, and those rated by the panel as most competitive are invited to provide a brief research proposal. An external review panel evaluates the proposals and ranks the candidates. Considering the rank order of the proposals and the Institute's overall objectives, the Institute's management selects awards to be recommended to the Institute's Trustees for authorization for funding.

Other International Activities

Other than the awards of the International Research Scholars Program described above, the Institute has made only one grant under the International Program. This is for joint activities by the U.S. National Academy of Sciences and the Mexican Academia de la Investigación Científica. Few additional awards are expected to be made. Applications, which will be considered on an individual basis, should be submitted only after consultation with the Grants Program management.

Program Assessment

Program assessment activities involve research conducted by various public and private agencies external to the Institute, as well as internal analyses. The external activities usually are conducted on the basis of contractual arrangements,

Correspondence and inquiries concerning the grants program should be directed to:

Joseph G. Perpich, M.D., J.D.
Vice President for Grants and Special Programs
(301) 215-8890

Barbara Filner, Ph.D.
Graduate Science Education Program and
International Research Scholars Program
(301) 215-8884

Stephen A. Barkanic
Undergraduate Science Education Program
(301) 215-8872

Kathi E. Hanna, Ph.D.
Precollege and Public Science Education Program
(301) 215-8873

David L. Davis-Van Atta
Program Assessment
(301) 215-8872

Howard Hughes Medical Institute
Office of Grants and Special Programs
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
Fax: (301) 215-8888

For publications and information on the Institute, contact:

Howard Hughes Medical Institute
Office of Communications
4000 Jones Bridge Road
Chevy Chase, MD 20815-6789
(301) 215-8855

at the Institute's initiative, for specific research projects. Thus, there is no grants program as such for program assessment activities.

Unsolicited Proposals

Although the Institute will consider unsolicited requests, grants are intended to support specific objectives through clearly defined programs. Thus, the Institute will only be able to respond favorably to a very small fraction of unsolicited proposals. The grants program does not support investigator-initiated research projects in the United States. Rather, the Institute, through its scientific program, employs independent investigators in Institute laboratories in leading universities, hospitals, and academic medical centers.

Initial correspondence to the Institute should be in the form of a brief letter outlining (1) the specific need and the approach proposed, (2) the institution's special capabilities for implementation, (3) the qualifications of the proposed director of the project, (4) the general plan of action to meet the objectives, and (5) the estimated budget, timetable, and existing funds for the project.

Further information on the Institute's research programs, copies of the annual report, and other publications are available from the Office of Communications.

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Grants Publications

Comprehensive

Grants for Science Education (annual)

Meetings of Grantees

Scientific Meeting of Fellows, Program and Abstracts (annual)

Attracting Students to Science: Undergraduate and Precollege Programs, 1992

Enriching the Undergraduate Laboratory Experience, 1993.

1993 Undergraduate Program Directory

Program Announcements

Predoctoral Fellowships in Biological Sciences (annual)

Research Training Fellowships for Medical Students (annual)

Postdoctoral Research Fellowships for Physicians (annual)

Precollege Science Education Initiative for Museums (annual)

Undergraduate Biological Sciences Education Program (annual)

International Research Scholars Program (biennial)

Information Booklets

Information for Medical Student Fellows and Fellowship Institutions (annual)

Information for Predoctoral Fellows and Fellowship Institutions (annual)

Information for Physician Research Fellows and Fellowship Institutions (annual)

Information for Museums Awarded Grants (annual)

Information for Colleges and Universities Awarded Undergraduate Grants (annual)

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  International Research Scholars Program

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Howard Hughes Medical Institute
Office of Grants and Special Programs
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Chevy Chase, MD 20815-6789